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ABSTRACT

A landscape entails more than just a landform. It includes the associated local climates and plant communities. Outlined in a brochure is a resource kit designed to provide information and audiovisual materials to teachers interested in conducting studies in the landscape ecology of Southern Saskatchewan. Two of the items described in the brochure are included as part of this entry. The first is a reference manual about Saskatchewan landscapes, their use, misuse, and ecology. Following a general introduction, Chapter II emphasizes the care of the biosphere by identifying landscapes as complex ecological systems that must be understood before they can be managed. Chapter III describes common landforms of the province, their origins, and characteristics. Chapter IV reemphasizes the theme of "earth care" by elaborating upon the complex relationships among different components of the landscape and relationships among a system of landscapes. Chapter V addresses land use patterns and issues. Not included are seven audiovisual programs on different landscape types and seven colored posters. (DC)

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Landscapes:
Reference Manual

A Guide to the Landforms and Ecology of Southern Saskatchewan

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Saskatchewan
Environment

Landscapes:

A Guide to the Landforms and Ecology of Southern Saskatchewan

Reference Manual

by
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Editor
Robert J. Long

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Cover Photograph

The cover illustration is a vertical aerial photograph (Number A21639-81) taken from an altitude of about 9,150 metres (30,000 feet). The scale is about 25 millimetres to one kilometre, or 1.5 inches to the mile.

The area shown is the northeast edge of the Missouri Coteau, located southwest of Moose Jaw. Included in the photo are many landforms discussed in this manual. In the lower left, a pattern of parallel, curving ridges atop the Coteau highland represent an ice-thrust moraine. To the east is classical hummocky moraine, with numerous kettle ponds. Recent drainage patterns are superimposed on the moraine. To the northeast, the land is smooth and level. This plain is a portion of the bed of Glacial Lake Regina. Each landscape has characteristic soils. This, combined with the topography, has dictated the type of use the area has been put to by man.

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Foreword

The idea behind this manual is earth care, a theme given universal support at the 1972 Stockholm Conference on the Human Environment. There the nations proclaimed that protection of the environment is the duty of all governments, and subsequently the UN General Assembly declared that safeguarding the environment is essential to "the enjoyment of basic human rights — even the right to life itself".

The aim here is to encourage an understanding, affection and concern for the Saskatchewan environment. Emphasis is on understanding landscapes, so that their uses may be well planned to the ends of maintenance and preservation.

This manual is part of a kit that also includes landscape guides, slide/tape programs, and a terrain map. The seven guides to distinctive types of terrain, with the manual as background, will assist in understanding some of the features and processes of the province's plains, hilly areas, valleys, flood plains, marshes, drylands, and dunes. The terrain map will serve to guide interested people to the different types of landscapes south of 53 degrees latitude. The slide sets provide introductions to the seven major landscapes found in south Saskatchewan.

Many people contributed constructive criticisms and advice during preparation of the manuscript. Particularly I want to acknowledge the assistance of the following: E. A. Christiansen, Saskatchewan Research Council; D. F. Acton and J. G. Ellis, Saskatchewan Soil Survey; W. O. Kupsch, Department of Geology, University of Saskatchewan; J. B. Gollop and R. E. G. Murray, Canadian Wildlife Service; R. T. Coupland, R. E. Redmann, E. A. Ripley and N. A. Skoglund, Department of Plant Ecology, University of Saskatchewan; M. E. Jonescu, Saskatchewan Environmental Advisory Council; P. Hart, Saskatchewan Department of the Environment; S. M. Haggerty, Saskatchewan Department of Education.

Any errors of interpretation of landscape features are my responsibility, as of course are the opinions expressed throughout the text. I thank the Department of the Environment, and Mr. Fred Heal especially, for providing the means and the encouragement to undertake this project.

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Figure 1 - Frontispiece - The Simple Life

I. Introduction

Saskatchewan is a beautiful province, full of scenic wonders from the big-sky prairies in the south to the clear lakes and evergreen forests of the north. The beauty found in our surroundings is not just a happy chance; it has meaning. The delight in a view of the Qu'Appelle Valley from its high edge, in bird songs as the sun sets over Waskesiu Lake, in the scent of balsam as the spring buds of black poplar open beside creeks and ponds is shared by everyone whose senses are working. It tells us that we are earthlings; brought forth and nourished by the air, water and land of the planet during its four billion years of evolution. We are tuned into its sights, sounds and odours so that we recognize, almost instinctively, what is healthy and beautiful and what is unhealthy and ugly in our surroundings.

The fact that our ancestors did not live and evolve in Saskatchewan, and that we are all descendants of migrants, is not important. Our forebears — whether from Asia, Africa or Europe — lived in and experienced a similar world. So in one generation, in any part of the world, each of us can feel "at home". In other words, every human being is adapted to the biosphere and not just to one part of it. We carry in us a natural sense of what is fit and good in the environment, and this sense can be further developed through experience and understanding.

The space in which each of us lives, be it forest, farm, town or city property, is a vital part of the whole earth. Each part, if well looked after, helps to keep the biosphere healthy and productive, providing directly and indirectly the food, fresh water, air and creature comforts that make life worth living. If there is to be a continuing good life here in Saskatchewan, earth care is the first requirement. But care of the earth requires understanding of the land and understanding of our dependencies on it. Particularly, every person should know his own country and accept responsibility for conserving it. Stewardship, like charity, has to begin at home.

This manual is about Saskatchewan landscapes, with particular attention to those south of the Precambrian Shield country. It examines how landscapes are "put together", and how they are used or misused. The aim is to encourage an affection for the environment — for the land that supports the people of this province — and also to encourage an understanding of the ecological necessities for good land management.

In Chapter II, the theme "caring for the biosphere" is developed by identifying the landscapes that surround us as ecological systems. These landscapes are a part of man's life. Their healthy functioning is vital to the continuing health and survival of humanity. The materials and the shapes that make up the land's surface have influenced the development of local climates, vegetation, animal communities, and soils in an interacting web, producing our visible landscape ecosystems. The structures and functions of these landscapes are worth studying. Only through an understanding of landscapes can there be a basis for sensitive land management.

Chapter III describes the common landforms of Saskatchewan, explaining their origins and the features by which they can be recognized, with reference to the work done by glaciers, and processes that have worked since the end of the ice age. The landforms and associated water bodies make up the foundation of our landscapes. In a very basic way, they determine what the land can be used for and what we must do to conserve it.

Chapter IV returns to the theme of Chapter II. It launches a more detailed explanation of the relationships among components of the landscape. The idea of "catenas" is introduced. These are sequences of small, interlinked landscapes that are fitted to small local variations within a landscape. They are examples of how the landform, soils, climates, and living organisms change together so that they fit in a system that will work. Attention is drawn to the excessive pressures on the land that are caused by the expansion of the human population and of high-energy technology.

Chapter V deals with the way we use land, and with the attitudes that have led to misuses. This section does not require a close familiarity with the preceding chapters, although they help one to understand the land and the problems related to land use. Some suggestions and guidelines for ecological land use planning are given.

Finally, a glossary of technical terms and a list of references are provided. The latter is no more than an introduction to the literature, for we have room to mention only a few of the many excellent publications that deal with the Natural History of Saskatchewan.

The common names of plants and animals have been used throughout the text. Those interested in the taxonomic names will find them in the standard textbooks covering the flora and fauna of the province.

II. Landscapes as Ecological Systems

1. Introduction

How we look at the world makes a difference. The things that we identify as important get special attention and care while all the rest is apt to be neglected. Our sense of what is important comes partly from our tradition and culture and partly from our own experience and thought. In western culture, neither our tradition nor our experience has made us look at the world as being important or sacred. Instead we have been encouraged to view the world as a temporary stopping place on the road to a better life hereafter. When man is perceived as the only thing that is valuable, the stage is set for widespread mistreatment of land and landscape, water, soil and organisms. We usually think that *nothing matters but man's interests*. Shall we plough up the last prairie, dam the last wild river, harpoon the last great whale and club the last seal pup? If only we are important, the answer must be "yes".

Despite what tradition tells us, by thinking about these matters we can see that we are not so all-fired important. Toning down our bravado with a certain amount of humility is the essence of wisdom. For man is dependent on the world, on the living system in which he is immersed. It is a complex of ecological systems of which he is only one part among many.

One way that humans have learned to understand the natural world is by looking at its various parts. We understand that our bodies are composed of organs such as the heart and brain, and these in turn are collections of cells that contain organelles that are made of molecules made of atoms made of sub-atomic particles. All the things around us seem to be composed of parts; they have "anatomy" which means that they can be "cut up" into other things. The land environment in which we live is also a system composed of sub-systems, and the entire common sense world can be thought of as systems within systems, like sets of Chinese boxes that fit one within another. Sub-systems are related to the larger systems by the functions that they serve. The legs of a chair support the seat and back, and that is their purpose with respect to the chair. The parts or sub-systems (legs, seat, back) are only important because they are part of the whole system (chair). Similarly, in the living world, the organs and tissues that comprise the human body play necessary roles in sustaining the body, keeping it healthy and functional. The role or purpose of the heart is to pump oxygenated blood to the other organs and tissues. Without the heart the body would die, while without the body there would not be a heart nor any need for one.

Figure 2 - The Heart - Person System

The ecology of the heart has to do with the relationship of heart to body, i.e. with the sub-system's role in the larger system that surrounds it. A healthy heart helps the body to be well; a well body maintains a healthy heart.

If, like an untrained actor in a play, the sub-system plays its role poorly, then either the play "flops" or the bad actor is replaced by a better one. In either case the useless part (the bad actor) is eliminated. It is an iron rule that sub-systems must *serve* the systems whose parts they are or be discarded. The broken-legged chair that can no longer fulfill its function is set aside; the body with the defective heart dies. Sometimes if the fault is caught in time it can be corrected and the system continues its organized functions. Is man today a healthy or a faulty part of the world's living system? If the latter is true, what corrective measures are required? The study of ecology may be helpful.

2. Ecology and Ecosystems

We usually define **ecology** as the study of organisms in relation to their environment. It is better to think of ecology as "the study of the role of parts in relation to their larger surrounding wholes". This helps us to understand the interactions of man and land in a realistic way.

Notice that ecology can be the study of *any* sub-system in relation to the surrounding system — its environment. It does not apply only to organisms. Water bodies, soils, and local climates also have ecological relationships with their surroundings. To be most meaningful, "environment" must be thought of as a **whole system** rather than an unrelated mixture of factors such as light, heat, moisture, and nutrients. "Factors" are really anatomical parts, picked out by man-made measuring instruments which react to bits and pieces of complex environmental systems. They are also creations of language, which tags names on the measurable bits and pieces, misleading us into believing that separate, discrete factors actually exist.

What system or systems constitute the environments of interest around us? Considering again the Chinese boxes, there are many environmental systems that can be defined, each nested in larger surrounding ones. For example, most people in Saskatchewan live in a family-unit house (a system of which they are parts) that lies within a town or city, in a geographic region (grassland or forest), in a continent (North America) that is a part of the planet earth's surface (the biosphere). The general name for every system above the level of the organism is "ecosystem", or ecological system.

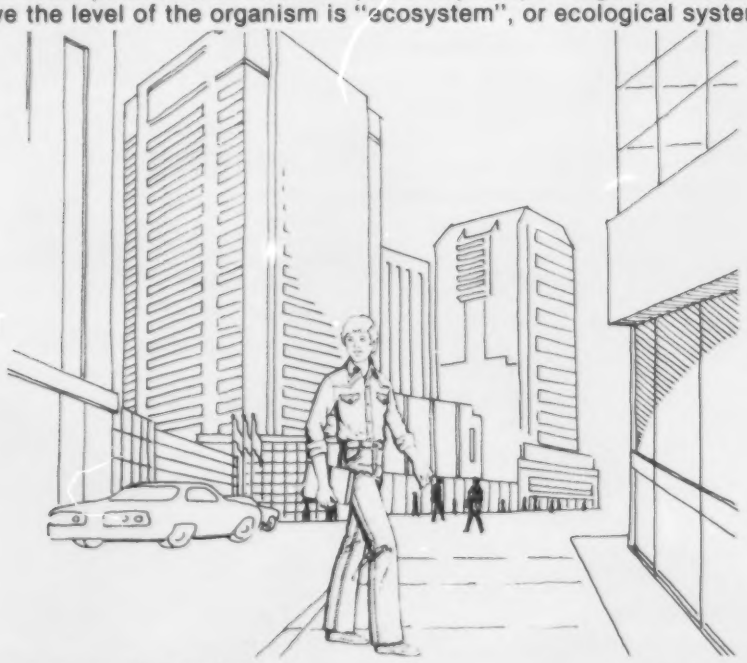


Figure 3 - The Person - City System

The ecology of the city-dweller concerns the mutual relationship between him and the city; that is, it has to do with the sub-system's role in the ecosystem that surrounds it. A healthy human helps the city to be well; a well city maintains healthy people.

Organisms such as ourselves come into being, live, die and recycle as parts of ecosystems, from the small and nearby systems to the all-inclusive world biosphere. By the same logic, cities and towns with their populations also have essential ecological relationships; namely, their interactions with the larger areas in which they are located. The ecology of Regina or Saskatoon relates each city to the surrounding agricultural plains and more distant landscapes. Water, air, energy, and materials are drawn from surrounding areas. Goods, services, and wastes are contributed to them.

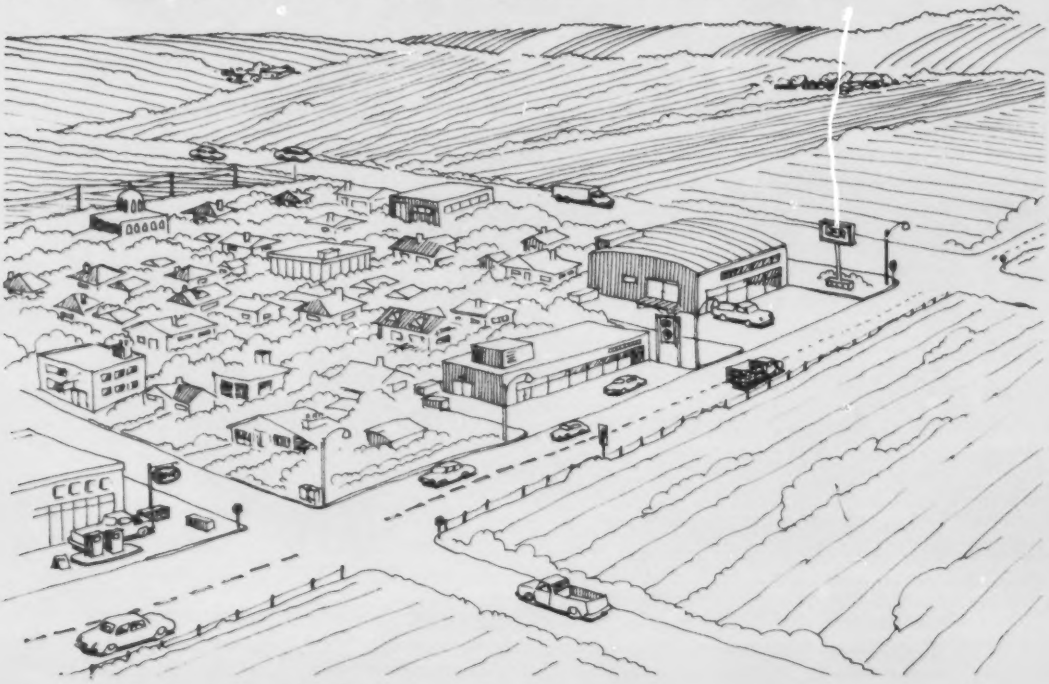


Figure 4 - The City - Countryside System
The ecology of a city has to do with its interrelationships with the surrounding region. A healthy city looks after the well-being of the region; a well-kept region maintains healthy cities and towns.

This manual focuses on moderate-sized landscape ecosystems within which man has developed his communities and farms. They make up the Saskatchewan land environments — our immediate life-support systems. They are the indispensable sources of food and fibre, water and minerals, recreation and outdoor enjoyment. They are structured systems that have developed through the interaction of earth, air, water, organisms, and energy from the sun. Landscapes are the environment man developed in; they influence what we are, and even how we think and feel.

3. Structure and Development of Landscape Ecosystems

The landscape ecosystems that we see around us — grassy hills, wooded valleys, marshy plains — are the earth's thin living skin, formed under the influence of forces such as sunlight, precipitation, and gravity. The force of gravity produces a horizontal layering that is especially noticeable in cross-sections. A slice through the landscape on a steep riverbank or on a recent road cut reveals characteristic horizontal layers. At the bottom are the rocks and glacial deposits formed long ago. The soil and the vegetation on top are more recently formed layers. Although sloughs and lakes cannot be sliced open for examination, they also have layered profiles both in the water and in the bottom sediments. In the same way, there are characteristic invisible layers in the air that forms the upper part of both terrestrial and aquatic ecosystems. With instruments such

as thermometers, hygrometers and anemometers they can be "sensed" as layers of different warmth, moistness, turbulence, and so forth.

The air, vegetation, soil and rock layers that can either be seen or sensed represent related parts of a landscape. Like organs in an organism, they play essential roles in the environment as a whole. Every layered soil supports green plant layers whose leaf-fall and roots help to form it. The vegetation mantle draws from the soil its nutrients and moisture, and in turn transfers most of the moisture to the air which it humidifies and helps to structure. At the same time the plant layers moderate the effects of rain and solar energy on the surface so that erosion is slowed and both vegetation and soils can hold on. In these ways, the landscape's layers influence and adjust to one another.

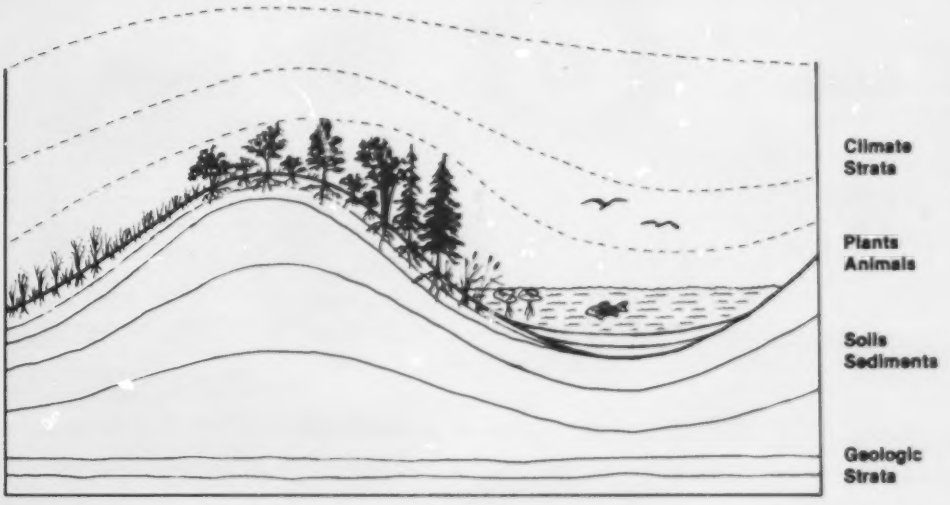


Figure 5 - The Layered Structure of Landscapes

All landscapes have structure. The air and earth layers are in a state of mutual adjustment, reflected in the forms and compositions of the vegetation, animal communities, soils and sediments.

The relationships of the layers that make up the profiles of Saskatchewan landscapes are more understandable if we consider the way they developed. Most of the province was covered by a large continental glacier that had disappeared south of Saskatoon about 12,000 years ago. As the ice melted and the meltwater lakes drained, a bare landscape emerged. its surface was composed of mineral deposits of different textures and shapes. On this foundation the different landscapes of today have developed. Some have forests and grey soils, and some have grass and brown soils. Regional differences are partly due to latitude and longitude which generally determine such important influences as the amount of sunlight energy received in the growing season, the frequency of inflows of cold arctic air, and the occurrence of rain and chinook winds. But, within major regions or life zones in the province, the climate is fairly uniform. The diversity of landscapes is primarily due to the variety of surface mineral materials and the shape of the deposits, i.e. the landforms.

Every landform affects the surface pattern of climates, living communities and soils on its surface. Each distinctive part of the landform has its own characteristics of slope direction and steepness, ability to absorb moisture, etc. These characteristics determine the amounts of sunshine energy and moisture in each part. Therefore, each part has its own local climate. On a sandhill the upper slopes are normally drier than the lower ones. The south-facing slopes are warmer than the north-facing ones that are shaded from the sun. The hilltops are relatively exposed to the wind, so they are cooler during the day and warmer at night than the less windy hollows.

As glaciation ended, each emerging landform caused a patchwork of climates fitted to the different parts of its surface.

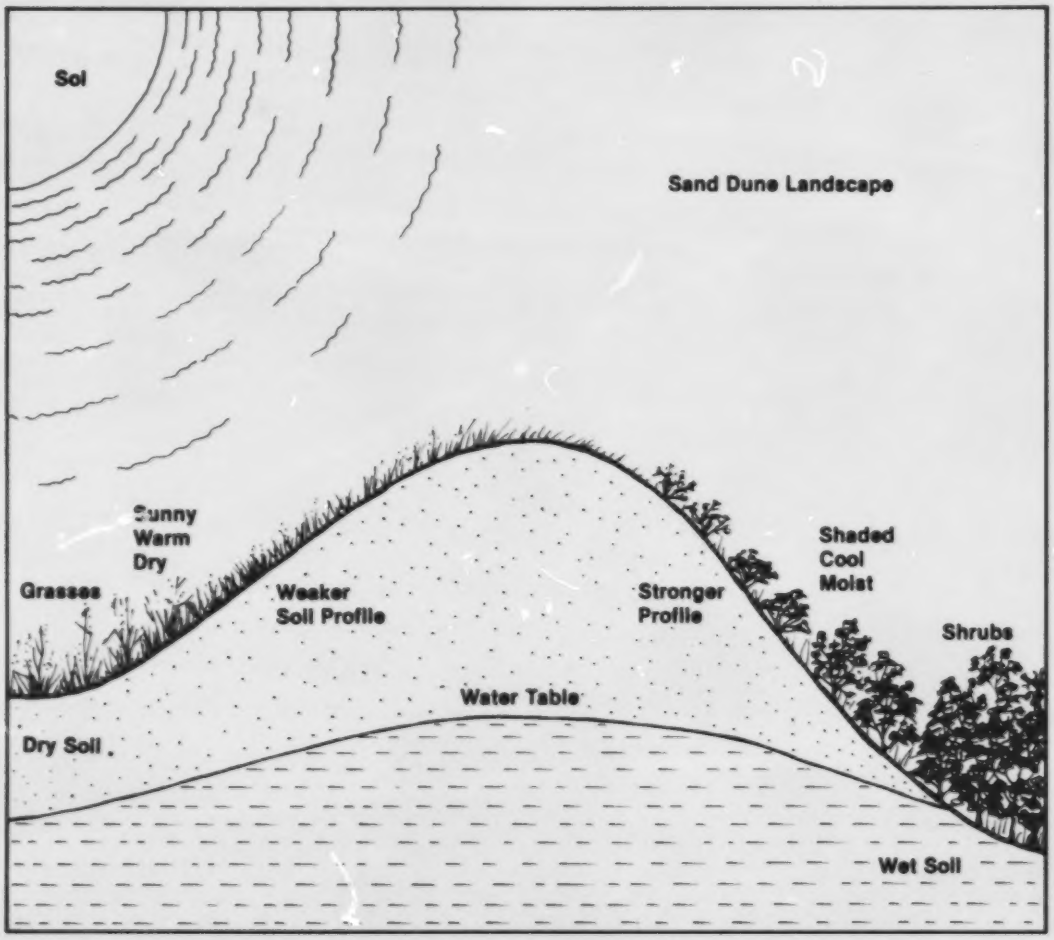


Figure 6 - Influence of Landform Slopes on Biotic Communities and Soils
An illustration of the control of local climates, vegetations and soils by a landform. The amounts of radiation and moisture available to the biota are controlled by the topography and sand composition of the dune. There is groundwater discharge.

Next in time, the plants arrived to clothe the surfaces. Their seeds and spores migrated in from unglaciated areas to the south and west. Then, as now, each species had a distinctive set of environmental factors that it needed in order to grow. It required a specific range of moisture, sunshine, and temperature if it was to survive. When a seed came to rest on a part of a landform, one of two results was possible. Either it found that particular environment unsuitable, and died; or it germinated and grew and became a successfully reproducing plant. In either case, the initial control was exerted through a particular landform-climate which selected those new arrivals that were "fit" to form its vegetation. The first expression of natural selection is this acceptance or rejection of potential colonizers by different parts of the landform and the local climates attached to them.

Once established, the early plants also became part of the selection process. They influenced the survival of later-arriving competitors. Gradually a complex of vegetation formed, providing a variety of energy sources for large animals and for small organisms like fungi and bacteria. Mutually beneficial relationships were established, for plants

need animals just as animals need plants. In time, each part of the landform supported a complete **biotic community** that was appropriate to it.

At the same time that the plants and animals were becoming established, the landforms and their climates were adjusting somewhat to the presence of the living organisms. Vegetation changed the climate near the ground, influencing temperature and moisture through leaf shade and transpiration. Plant remains added to the surface layer increased the activity of plants and animals, micro-organisms, and nutrients. Roots channelled the mineral matter and removed salts. One result was the development of **soils**, each type matched to its particular part of the landform-climate-biota system. Each different soil is the result of a history of interactions between mineral substratum, landform, local climate, plants, animals and micro-organisms.

In summary, every landscape of Saskatchewan is composed of a landform base on which a mutually adjusted pattern of climate-biota-soil has developed. In turn, each surface pattern has affected the composition and shape of the supporting landform. There is "feedback" between the landscape parts, so that when any one part is disturbed the effect reverberates through the whole.

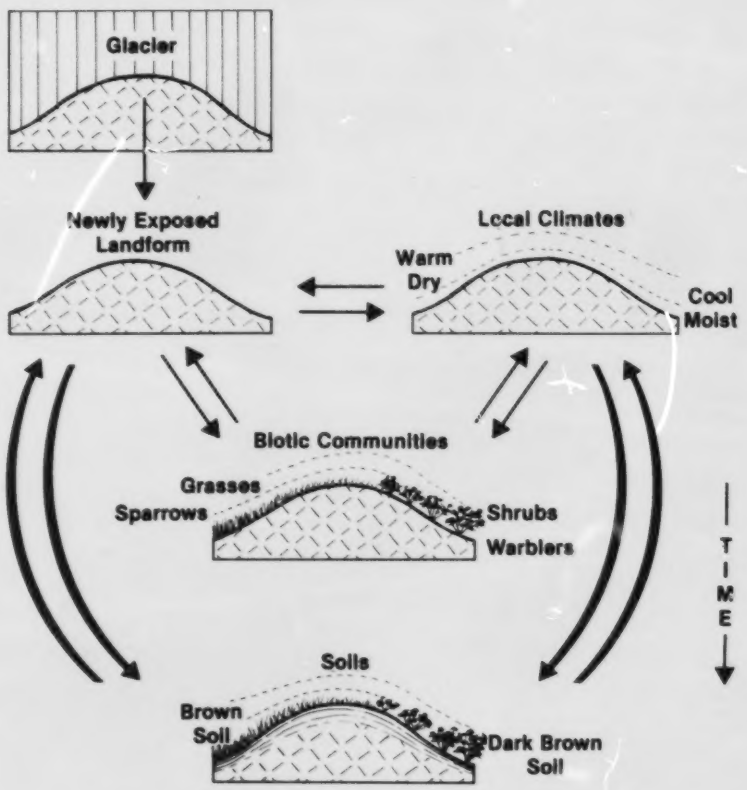


Figure 7 - Landscape Development Since Glaciation

Landscape development on a hill exposed after glaciation. In a mutually adjusting sequence, local climates, biotic communities and soils appropriate to the different slopes are formed. In turn each slope adjusts to its climate, biota and soil, the arrows indicating the relationships of all the landscape components.

In order to gain some understanding of surrounding landscapes, the relationships of the climate, living organisms, soil, landform, and geology need to be understood. Each provides clues to the functions of the others and of the whole. Figure 8 illustrates the fields of study that contribute to understanding the land environment.

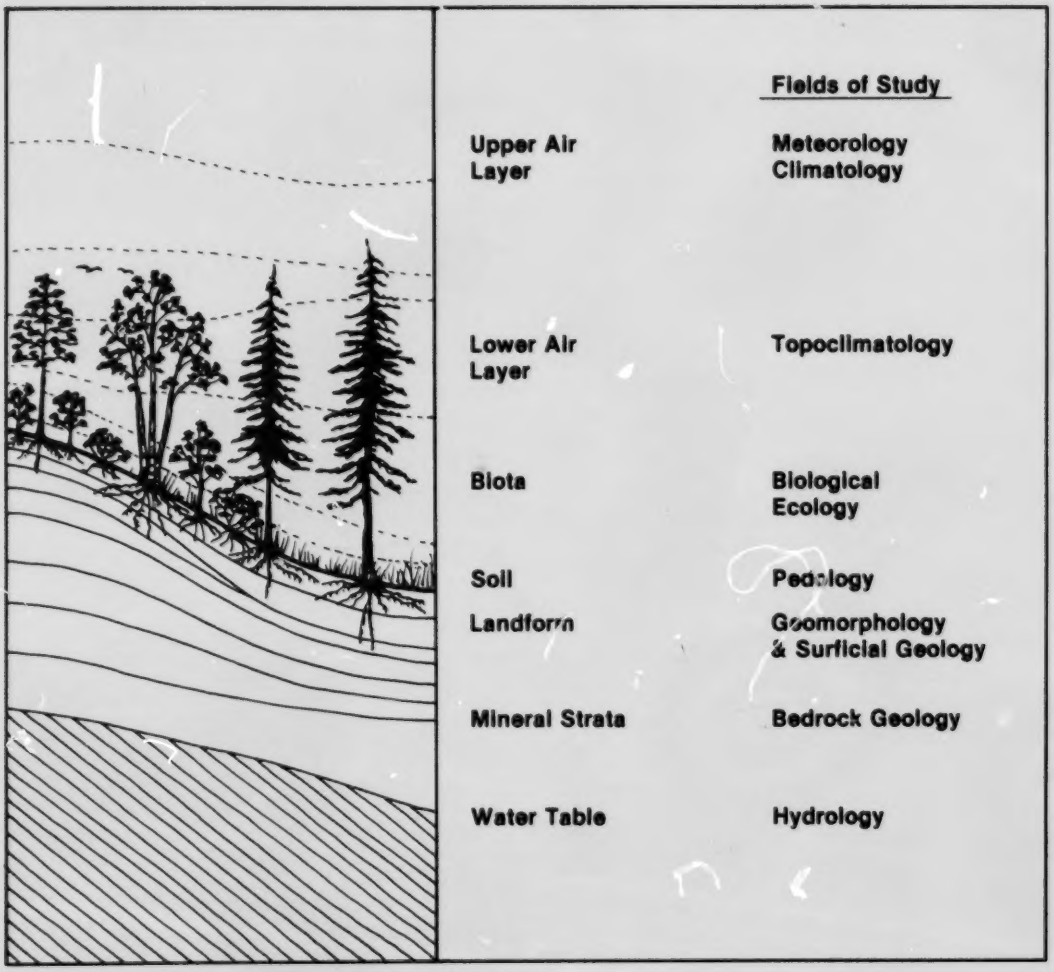


Figure 8 - Some Ecological Fields of Study
The vertical structure of landscape ecosystems and the fields of analytic study.

Landscape ecology, or terrain ecology, aims at understanding the relationship of the biological and earth sciences in regional and local landscapes. A further aim is to gain insight into how landscapes, and particularly their biotic parts, will react to stresses placed on them by man. The important questions are of this type: What is likely to happen when components are changed (native vegetation replaced with cereal crops), when parts are removed as "resources" (gravel mined or forests logged), when energy and materials are added (soil irrigated or fertilized), when man-made objects are introduced (roadways and pipelines constructed)? Studies directed to such practical ends are called "environmental impact assessment". Most governments now consider such studies a necessity in advance of proposed major developments.

4. Landscape Ecosystems and Human Ecology

The human species evolved as part of landscape ecosystems. Small family groups and tribes travelled from place to place learning the use of tools and fire, harvesting the

sun's energy by hunting and gathering vegetable food. According to some authorities, man's distinctive upright posture, two-legged locomotion, keen eyesight and agile fingers signify adaptation to an open woodland or savanna environment. Perhaps this is why in the grasslands we like to plant some trees, and why in wooded parts of the country people place a high value on their lawns.

Town living is a recent enterprise, dating from Neolithic times a scant 10,000 years ago. It was then that the possibilities of growing crops were first discovered, allowing the change from a wandering way of life to a more settled one. But during most of the history of our species, "home" has been the open hills and wooded valleys, the lake shores and grassy plains. Here man, amid many kinds of plants and animals, lived according to instinct and habits, working, creating, playing, reproducing and finally returning to the earth. The ancestral memory is strong, and for recreation (which means "re-creation") people today leave the city to play out the ancient way of life: picking berries, wandering through the woods, fishing, climbing hills, camping beside the waters, watching the stars and the northern lights at night.

Because our ancestors lived, survived and evolved for millions of years within landscape ecosystems, as part of those systems, their ecological relationships must have been good. Had man not played a satisfactory role so far as the land was concerned, he would have been eliminated and replaced like any other faulty part. As the heart must serve the body to survive, so man must serve the biosphere to survive.

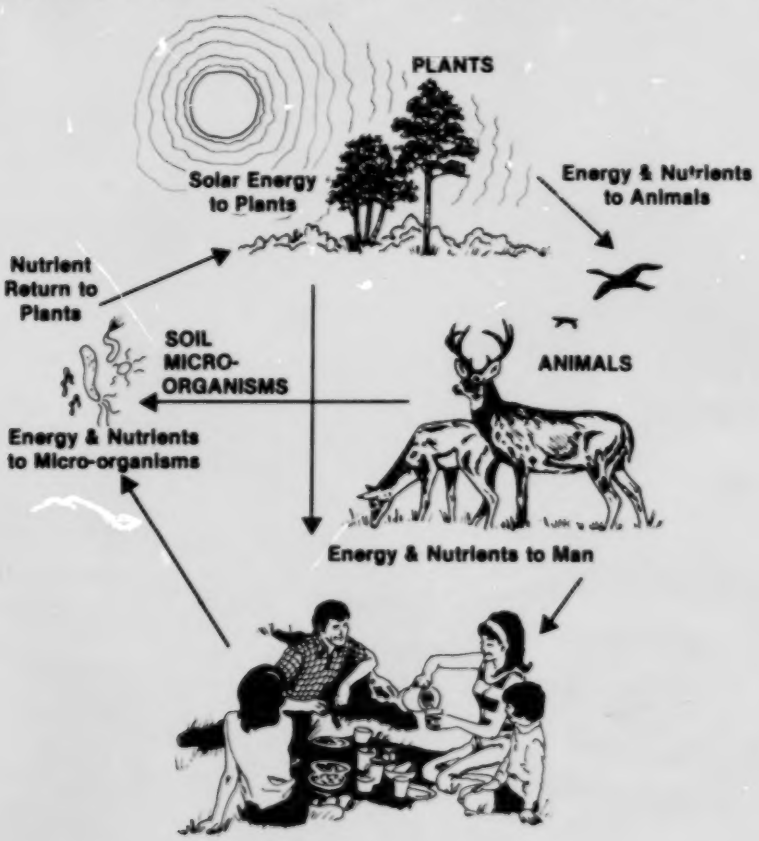


Figure 9 - The Simple Life
The simple life: man gets vital energy from the sun through food plants and animals. Metabolic wastes are broken down by mirco-organisms and the nutrients are recycled.

But modern man has come a long way from the stone-age gardeners who lived in small communities and used simple tools. Back then, "doing what comes naturally" was appropriate because, even with occasional wrong choices, human numbers and technologies were seldom large and powerful enough to cause a breakdown of the ecosystem. Local misuses of water, soil, plants and animals were small enough to be self-healing. Today the situation is totally changed. Large, expanding populations armed with the latest technological inventions, powered by fossil fuels and atomic energy, are "developing" and rearranging the face of the earth at a rate that increases yearly. A giant mindless experiment is testing how far one part, the human species, can go in forcing the whole biosphere to serve it. In the human body such an expansion of one sub-system at the expense of the whole body is called cancer. Frequently it is fatal. Clearly the course that the large and powerful nations are following poses dangers to the health of the biosphere.

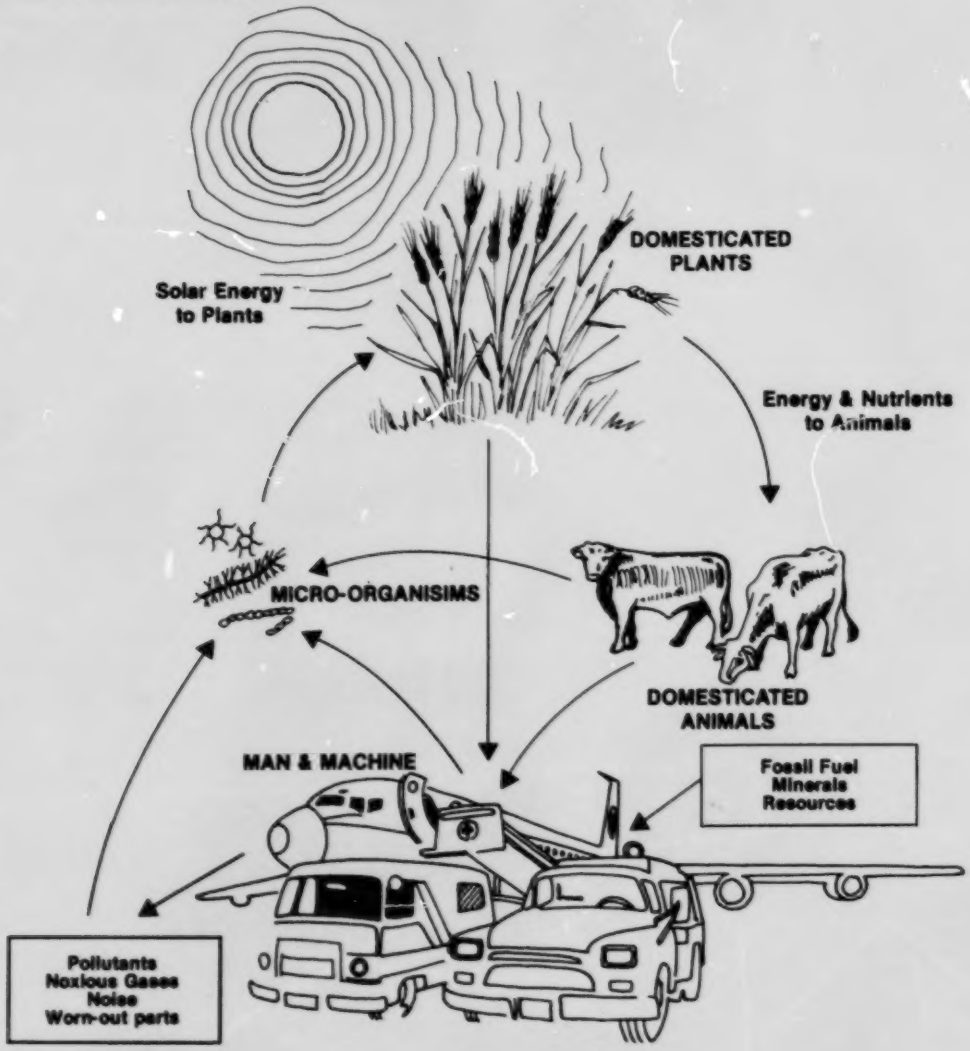


Figure 10 - The Complex Life

Man still gets his bodily energy from the sun through plants and animals (domesticated) but now he also uses highly concentrated energy and resources to metabolize machines. Some pollutant wastes resist breakdown by micro-organisms; they do not recycle in healthy ways.

There is a great need to understand how the world "works" and how the human species can fit itself to the renewing processes of the environment, contributing to the biosphere in a postive and creative way. But are we ready to "serve" the biosphere — the landscape ecosystems of the world and of Saskatchewan? Service implies knowing the right things to do, which in turn implies deep understanding and wisdom. Yet the greatest insight available today is the humble recognition that very little is known about our lands and about how they function within the world system. We have little idea of the extent to which they can be tampered with, stressed, poisoned with pollutants or forced to produce beyond what is normal. These surrounding systems that we are part of have a mind-boggling complexity. They represent four billion years of slow change and intricate adjustment.

The only completely safe and sure way to "serve the biosphere" is to let it be, to preserve and protect. Large areas of the province should be designated for such gentle uses or non-uses as wilderness, natural areas, parks and protected waterways. Yet obviously this cannot be the whole answer. Man must live in landscape ecosystems, taking and using resources from them. Therefore, we must try to understand how the earth's landscape systems work, so that we can use and manage them without permanently damaging them.

III. The Body of the Landscape; Landforms and Water

1. Introduction

A landscape consists of mineral matter that is shaped in one way or another, plus water, air and living organisms. The essential "body" is the landform, a three-dimensional surface shape plus its underlying geological materials. Landscape ecology therefore begins with landforms, with uplands and lowlands, hills, valleys and plains. Such major landforms, and their parts, have had the strongest influence on the evolution of landscapes, and they are still the basis on which today's landscapes work. In order to understand the ecology of the land, it is essential that we be able to recognize the different kinds of landforms and appreciate their roles. Geological history provides a helpful introduction.

In this section, the origin of bedrock and surface materials is discussed. The term "bedrock" is applied to all materials that were present before the land was glaciated, whether or not the deposits are really solid rock. A layer of marine clay beneath glacial deposits is considered bedrock even though it may be very soft. The bedrock surface is what the first glaciers had to "play with" as they worked over the landscape. In the southern part of the province, most of the bedrock is now deeply buried under glacial deposits, and the present land surface owes most of its present shape to the work of glaciers as they advanced or melted back.

After the ice withdrew, water and wind continued the processes of erosion and deposition. The present-day landforms of all sizes tell their own histories, reflecting the way that they were formed. We will discuss primarily what may be called "local landforms", meaning those of moderate size that can be recognized near most Saskatchewan communities. Examples are patches of sand dunes, coulees and valleys, rolling upland hills and lake-bottom plains on which many towns and cities are built. Such local landforms have histories that we can understand quite easily. They also provide a suitable base for explaining landscape differences, for an introduction to landscape ecology, and for the practical purposes of environmental management and land use planning.

2. Preglacial Physiography

The word "physiography" refers to the physical geography of an area — to the shape and contours of its surface. In Saskatchewan, the major physiographic divisions and features had already appeared prior to the glacial period (called the Quaternary Period) (Figure 11) over one million years ago. By then, water erosion had largely stripped the surface of northern Saskatchewan down to a rolling, hard-rock plain — the Precambrian Shield. These ancient basement rocks sloped downward to the south and west, forming a bedrock basin in which beds of sedimentary rock accumulated.

Lowest and oldest of the sedimentary deposits are the Paleozoic layers, which appear as a limestone-dolomite plain east of Lac La Ronge. Highest and youngest are the Tertiary strata of the Cypress Hills and Wood Mountain uplands.

Between these two extremes are beds of shale and sandstone of Mesozoic (Cretaceous) age. They formed much of the surface of Saskatchewan between the Paleozoic lowlands and the Tertiary highlands. The Cretaceous layers are of particular interest because they underlie most of the farming area of the province.

GEOLOGICAL TIME CHART			Millions of Years before Present
CENOZOIC	QUATERNARY	PLEISTOCENE (last 10,000 years)	1
	TERTIARY	PLIOCENE	11
		MIOCENE	25
		OLIGOCENE	40
		EOCENE	60
		PALEOCENE	70
MESOZOIC		CRETACEOUS	135
		JURASSIC	180
		TRIASSIC	225
PALEOZOIC		PERMIAN	270
		CARBONIFEROUS	350
		DEVONIAN	400
		SILURIAN	440
		ORDOVICIAN	500
		CAMBRIAN	600
		PRECAMBRIAN	

Figure 11 - Geological Time Scale

In the period that extended roughly from 120 to 60 million years ago, a great inland seaway extended through the middle of the continent, from the Yukon to the Gulf of Mexico. The region that is now the Interior Plains of North America was flooded by seas that shrank or expanded as the continent's Pacific coast lifted or subsided. When mountains in the west were actively rising, stream erosion from them built massive sandy alluvial fans into western Saskatchewan, forcing the sea to retreat eastward. When the mountains were quiet for a while, the sea returned and, in its waters, muddy sediments were laid down over the sandy alluvium. Therefore the bedrock is built of alternating eastward-thinning wedges of sand and silt (freshwater deposits) and westward-thinning wedges of clay and silt (marine deposits). To the east, the freshwater deposits are missing, and the bedrock consists solely of marine shales.

In the preglacial landscape of Saskatchewan, broad rivers with a northward trend had developed. Their valleys had isolated the highlands of Moose Mountain, Duck Mountain, Porcupine Hills, Pasquia Hills and Wapawekka Hills.

South of the Shield there were also some extensive basins, apparently formed where blocks of the bedrock had sunk. Such collapse structures are believed to be due to removal by percolating ground water of soluble beds (potash and other salts of Devonian age) that lie some 900m (3000ft) below the present-day surface. Lakes probably occupied these low spots, for freshwater sediments are found in them, buried under the later glacial deposits.

It is likely that much of the south of the province had a "badland" appearance similar to the landscapes that exist today near Avonlea, Big Muddy Valley, Rockglen and Killdeer. Stream erosion of the surface beds had exposed rather sterile sands, silts and clays. The combined deposition of marine and freshwater sediments, and subsequent erosion, created a surface topography as shown in Fugure 12. The highest areas are now in the southwest, so the surface slope is now opposite to the original slope of the Precambrian crystalline rock.

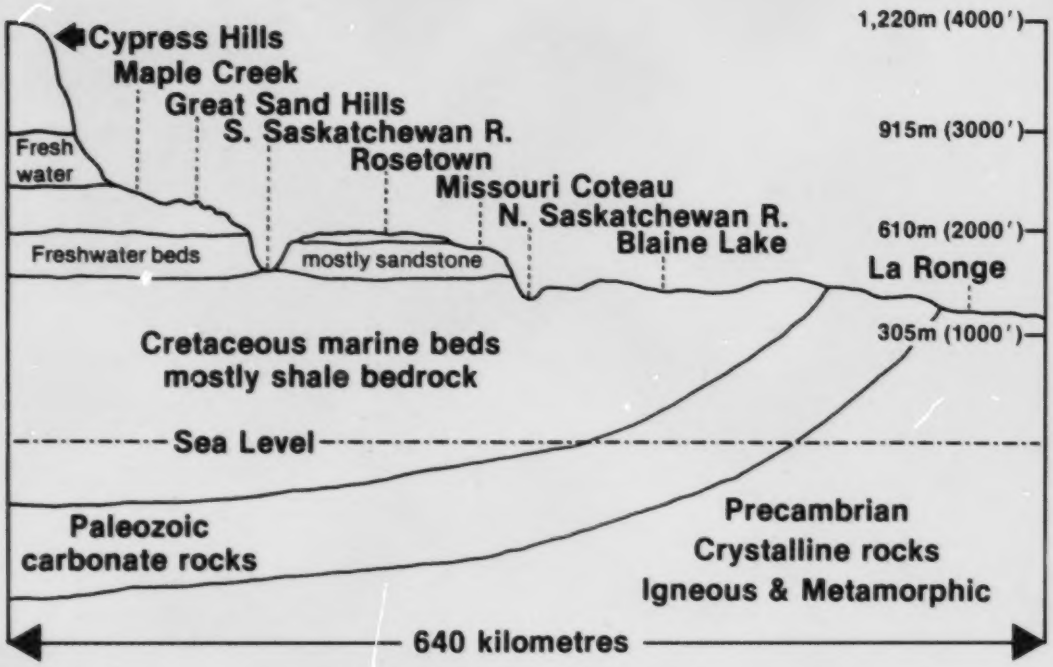


Figure 12 - Bedrock Levels

A 640 kilometre cross-section from La Ronge to the Cypress Hills shows a series of erosional levels in the bedrock. As the glaciers approached from the northeast, they were moving uphill.

Glaciation changed the scene greatly. The southward-moving ice sheets carried in a variable mixture of rock fragments scoured from the Shield and from the limestone beds bordering it. The fertile agricultural soils of the province owe a great deal to the transporting and blending powers of glaciers, as well as to the subsequent sorting effects of meltwater.

Although the multiple glaciations of the Quaternary Period brought great changes to the surface features of Saskatchewan, they did not eliminate the major preglacial landforms. In some places the old landforms were accentuated, where the ice steepened escarpments or piled debris on low hills. In other places the relief was subdued by the filling in of valleys and basins. But in general the landforms produced by glaciation were smaller forms superimposed on the bedrock topography. Major bedrock landforms are still recognizable. Useful maps depicting the physiography of the province have been published by Action et al. (1960) and, in modified form, by Richards and Fung (1969). Relief maps also convey a fairly accurate picture of the preglacial landscape (Figure 13). The geological and groundwater maps produced by the Saskatchewan Research Council provide a wealth of information on the bedrock surface and its mantle of sediments.

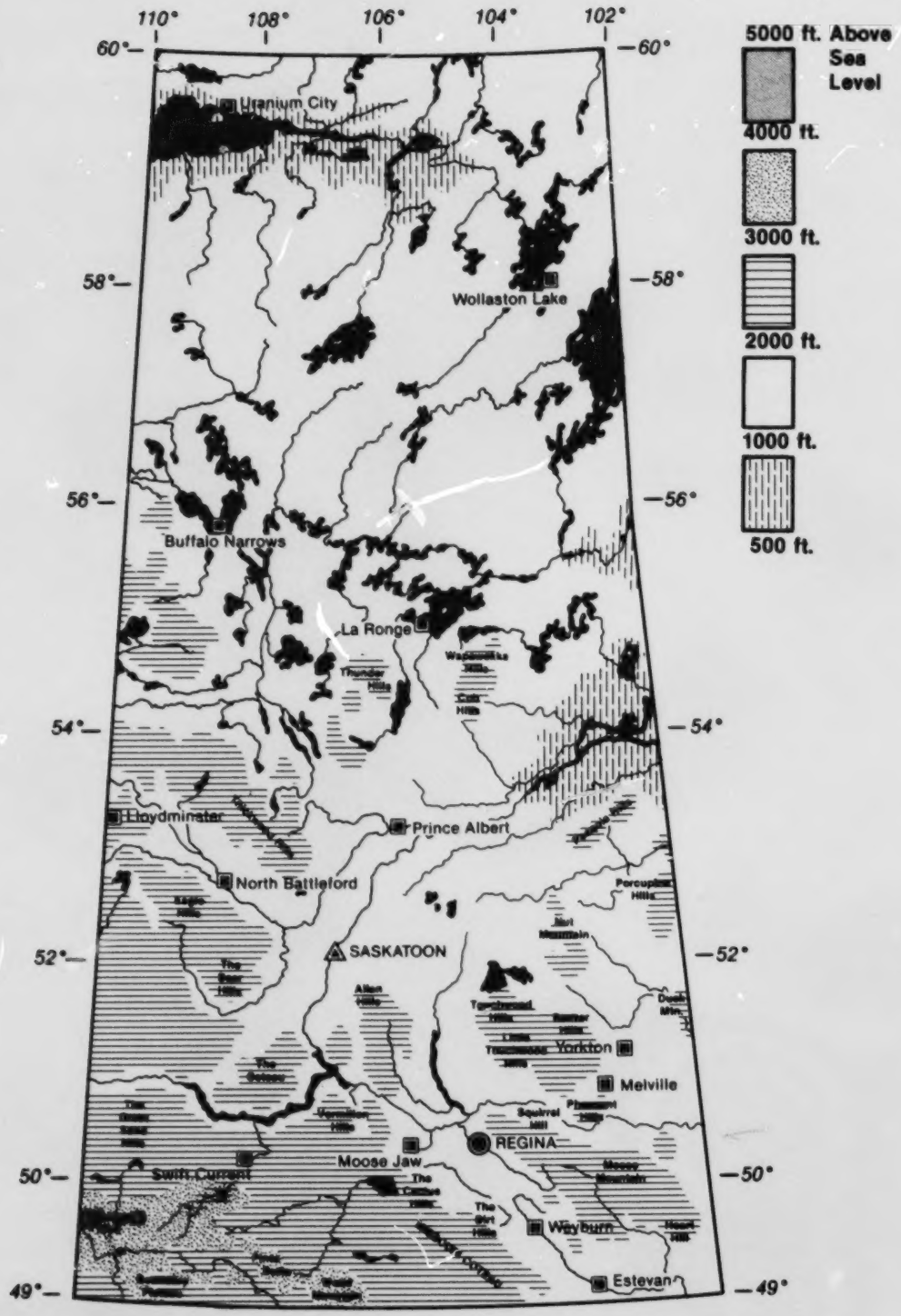


Figure 13 - Relief Map of Saskatchewan

3. Effects of Glaciation

In southern Saskatchewan there is evidence of three or four glaciations during the last million years or so, each major ice sheet depositing its own characteristic type of transported rock material or "till". Occasionally, along the cutbanks of valleys, one can see several different layers deposited down by the last two ice advances. Sometimes between the glacial deposits there are sandy and gravelly layers containing bones and teeth of extinct animals — horses, camels, mammoths, giant bison — indicating a warm ice-free time between two colder periods. In Saskatchewan, there is no surface evidence of glaciations which preceded the final two, but deep drilling has shown that additional buried layers of till lie on the old bedrock surface.

The size and weight of the last continental glacier is hard to imagine. Although the bedrock slopes from 275 metres above sea level near Hava Lake in the northeast, to 1370 metres in the Cypress Hills, the accumulation of ice over the Hudson Bay area was so great that the ice was squeezed outward, and pushed up the bedrock slope to the south. Most of the hills and plateaux in its path were covered.

At the glacial maximum, so much water was stored as ice that the seas were lowered by about 100 metres. This provided broad land bridges that temporarily allowed migration of plants, animals, and man between North America and Asia across the Bering Strait. The ice sheet reached a thickness of up to 3 kilometres (2 miles), and had such a tremendous weight that it actually depressed the earth's surface by almost a kilometre. The land in northern Canada is still rising, or "rebounding", from the release of pressure when the ice withdrew. Eventually, Hudson Bay may go dry as it lifts above sea level.

The enormous amounts of water produced by the melting glacier formed many large lakes and streams whose now dry basins and drainage channels characterize much of the landscapes of southern Saskatchewan. Most of the major cities and towns, and many farming areas of the province, are on the level bottoms of old glacial lakes.

Spectacular valleys and coulees, such as the Qu'Appelle and Saskatchewan, that criss-cross the province represent old drainage ways and meltwater channels.

Three classes of landforms are usually distinguished, based on the way they were formed.

Glacial landforms are those whose formation was directly influenced by the ice sheet.

Proglacial landforms resulted from glacial melting, from lakes and streams usually near the melting ice sheet.

Postglacial landforms are those unaffected directly by glaciation, formed under the influence of wind and water after the ice and the glacial meltwater disappeared. Some areas in the Cypress Hills and Wood Mountain were never glaciated, or only thinly glaciated. These "residual landforms" tend to be hilly or sliced up by gullies, and frequently they have "badland" features.

4. Glacial Landforms

Reference should be made here to the map "Landscapes of Southern Saskatchewan" which shows, colour-coded, the major areas of low wetlands, dry sandy and gravelly soils, intermediate plains constituting good farmland, hilly uplands with deep soils as well as those where bedrock is close to the surface, and valley systems. Within these major types, the capitalized symbols indicate the materials and processes from and by which the landscapes were formed, while the lower case symbols refer to features of the surface topography. Both are explained in the following sections.

Under the pressures produced by their great mass, glaciers flowed like thick molasses, eroding the ground beneath, and carrying along the resulting debris. This material included the entire range of particle sizes, from boulders the size of a house to the finest clay (Figure 14). This unsorted mixture of mineral debris is the till that has been deposited by melting ice on large areas of Saskatchewan.

Boulder		- anything over 256 mm in diameter
Cobble		- 64 mm - 256 mm
Pebble	Gravel	- 4 mm - 64 mm
Granule	Gravel	- 2 mm - 4 mm
Sand		- 0.05 mm - 2 mm
Silt		- 0.002 mm - 0.05 mm
Clay		- 0.002 mm or less

Figure 14 - Classification of Mineral Particles

In general, debris moved at the base of a glacier does not travel far, and the composition of till tends to reflect the composition of the local substratum. Thus on granitic bedrock north of La Ronge, tills are usually very stony and sandy, while on shale bedrock of southern Saskatchewan the tills are more likely to be a fairly even mixture of clay, silt and sand. However, this is not the entire story, for there is good evidence of long-distance transport of very large boulders (erratics) which must have been carried high in the glacier, or atop the ice. Some material must also have been carried in relays by successive ice advances, moving till southward by stages. Thus some tills near the international border contain a mixture of rocks and finer particles derived from the far-away Precambrian Shield and from the limestone outcrops along its southern edge.

On hillsides throughout much of the province's southland, boulders of speckled pinkish or grey granite can be found, along with occasional slabs of lighter dolomite and limestone splashed with red spots of the rock lichen *Caloplaca elegans*. The Indians used cobbles and small boulders to make the "tepee rings" and effigies that can still be found on unploughed hilltops and terraces. Larger erratics such as the famous Mistassini rock* near Elbow were of religious significance. Since the arrival of Europeans the fieldstone has occasionally been used to build homes or barns. In Saskatoon many of the university buildings are faced with attractive dolomitic limestone gathered from the surface till northeast and east of the city.

* The Mistassini rock is described as the "Aiktow Erratic" by W. O. Kupsch in the *Blue Jay* 21 (1): 2-4. 1963. The article "Largest Erratic in Saskatchewan?" also describes the Little Manitou Lake Big Rock.

The general name for the various landforms made of till is moraine. Several different types are distinguished by surface topography which reflects both the amount of till that was present in the ice as well as the way it was deposited as the various parts of the glacier melted back, stood still, or pushed forward.

(1) Till Plain (Ground Moraine)

Where till was left in relatively flat, featureless deposits, the resulting landform is referred to as a **till plain** or **ground moraine.** They were formed over large parts of southern Saskatchewan where the melting glacier "let down" a fairly even layer of moraine. This landform is more usual on lowlands than on uplands and there is evidence that its slight relief (less than 6m or 25 ft) and gentle slopes (less than 4 degrees) are due to the rapid melting of ice that contained relatively little debris. A high ratio of meltwater to till probably caused the till to flow out and assume an undulating topography that presents few obstacles, except some stoniness, to present day farming. Patterns on the surface of till plains as seen on aerial photographs reflect the mode of formation of several types, six of which are readily recognizable:

a) Featureless Till Plain
When viewed from the air, this landform shows little surface pattern. However, the rises are drier and lighter in tone than the adjacent lows, as in all terrain that is not absolutely flat. Shallow depressions occupied by ponds may be common. Some of them may be strung like beads along indistinct meltwater channels, but generally there is no orientation to their shape or distribution. Occasional low mounds and ridges of sand and gravel (kames and eskers, Figures 25 and 26) may be associated with meltwater channels.

b) Rimmed-kettle Moraine
Extensive areas of till plain often show a surface pattern of circular ridges with central hollows, like fields of giant doughnuts. These rimmed kettles are thought to have resulted from the insulating effect of till which had accumulated unevenly on the ice (Figure 15).

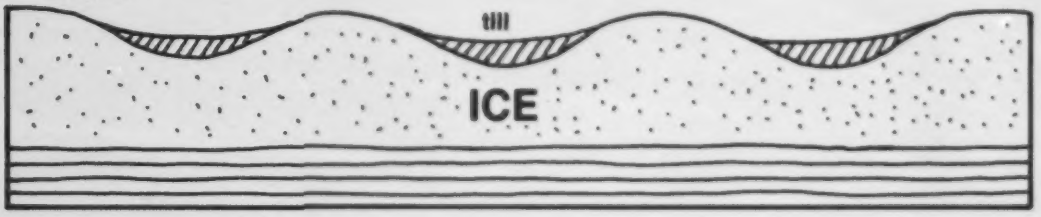
c) Linear-ridge (crevasse fill) Moraine
This ground moraine is streaked with long ridges up to 9 metres (30ft.) high, which are thought to have been formed when cracks in the ice were filled with till. The material in the linear ridges may have been squeezed up into the ice cracks from below or they may have accumulated from above by the slumping in of till released during melting. In some areas two sets of linear ridges are visible, intersecting each other at 45 or 90 degrees, forming a "waffle" pattern that indicates where a lobe of disintegrating ice once lay. During its decay, the ice probably fractured in more than one direction.

d) Washboard (ridged) Moraine
Near the outer edges of active glaciers the ice shears or slides along planes that parallel the shape of each lobe and that slope upward to the surface (Figure 16). Till is actually dragged up along these shear plains and extruded in parallel lines on top of the glacier's snout. The washboard pattern results when the ice melts, letting the lines of material down to ground level.

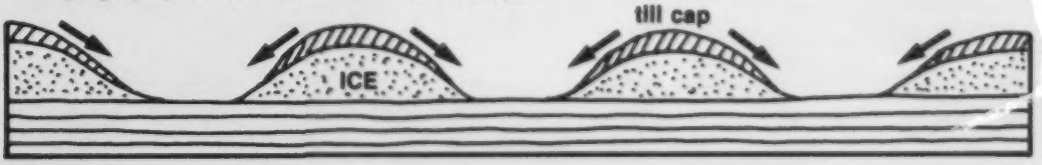
Ridged moraine may be created when crevasses open in "dead" ice and muddy till is squeezed up into the cracks by the weight of the ice. Today the extensive areas of ridged moraine, with swells and swales like a washboard surface, trace the fracture pattern of different positions of ice lobes as they stopped advancing. The ridges are difficult to see on the ground because they are usually only 2 to 9 metres (6 to 30 ft.) high, uneven in shape, widely separated and somewhat scattered. However, on air photos they are clearly visible as somewhat parallel light and dark arching ripples (Figure 17).

1. *Ice surface melts in humps and hollows. Till released by melting flows into hollows.*

2. *Till accumulated in hollows insulates underlying ice. Humps melt faster than hollows.*



3. *Topography reverses, till flows downslope.*



4. *Centre melts out.*

5. *Rimmed kettles*

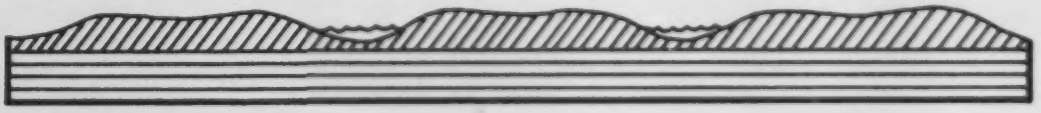


Figure 15 - Formation of Rimmed-kettle Moraine

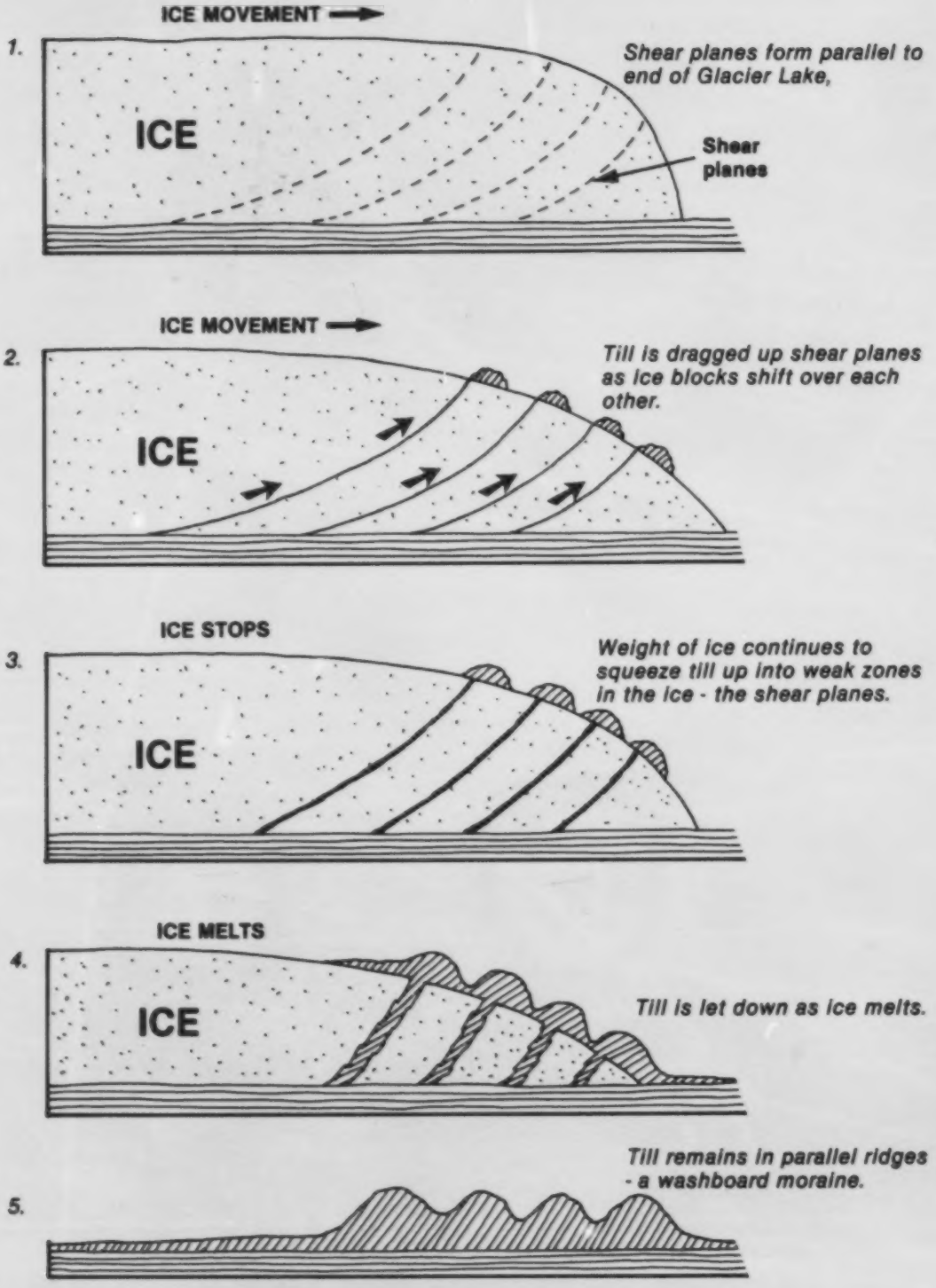


Figure 16 - Formation of Washboard Moraine

Figure 17 - Washboard Moraine
Located north of Moose Mountain, the moraine ridges show up as pale hilltops in cultivated fields. There is also a general east-west trend to ponds and groves of trees.

e) Drumlinized and Fluted Moraine
While washboard ridges form at a 90° angle to the direction of ice advance, streamlined till forms are characteristically parallel to the flow. Drumlins are ridges shaped like inverted spoons, formed as the thinning ice eroded and deposited basal materials (Figure 18). They are common features in northern Saskatchewan. More usual in the south are glacial grooves and low ridges that can occasionally be detected on till plains, looking like a series of long parallel lines that have been ruled on the landscape (Figure 19). Recent studies have shown that the grooves are eroded into previously deposited sediments.

f) Partly-filled Valleys
The remains of stream valleys, partly filled with till and occupied by chains of lakes, wind across most extensive areas of ground moraine. At least some of the large valleys pre-dated the last glaciation, for it is known in Saskatchewan that a whole system of major stream channels lies buried beneath the surface. These would have been overrun by the glacier, and at least partly filled with till as the ice finally melted (Figure 20).

Smaller valleys were eroded during glaciation, and many of them flowed between ice walls in decaying lobes of the glacier. During melting, till from on top of and within the ice would have slumped down into the channel, partly filling it, and creating a chain of ponds.

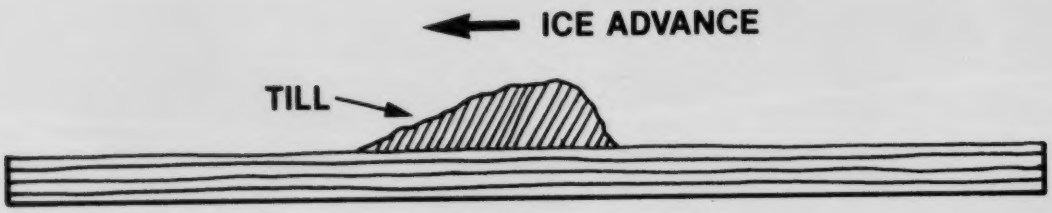


Figure 18 - Drumlin Profile

Figure 19 - Glacial Fluting

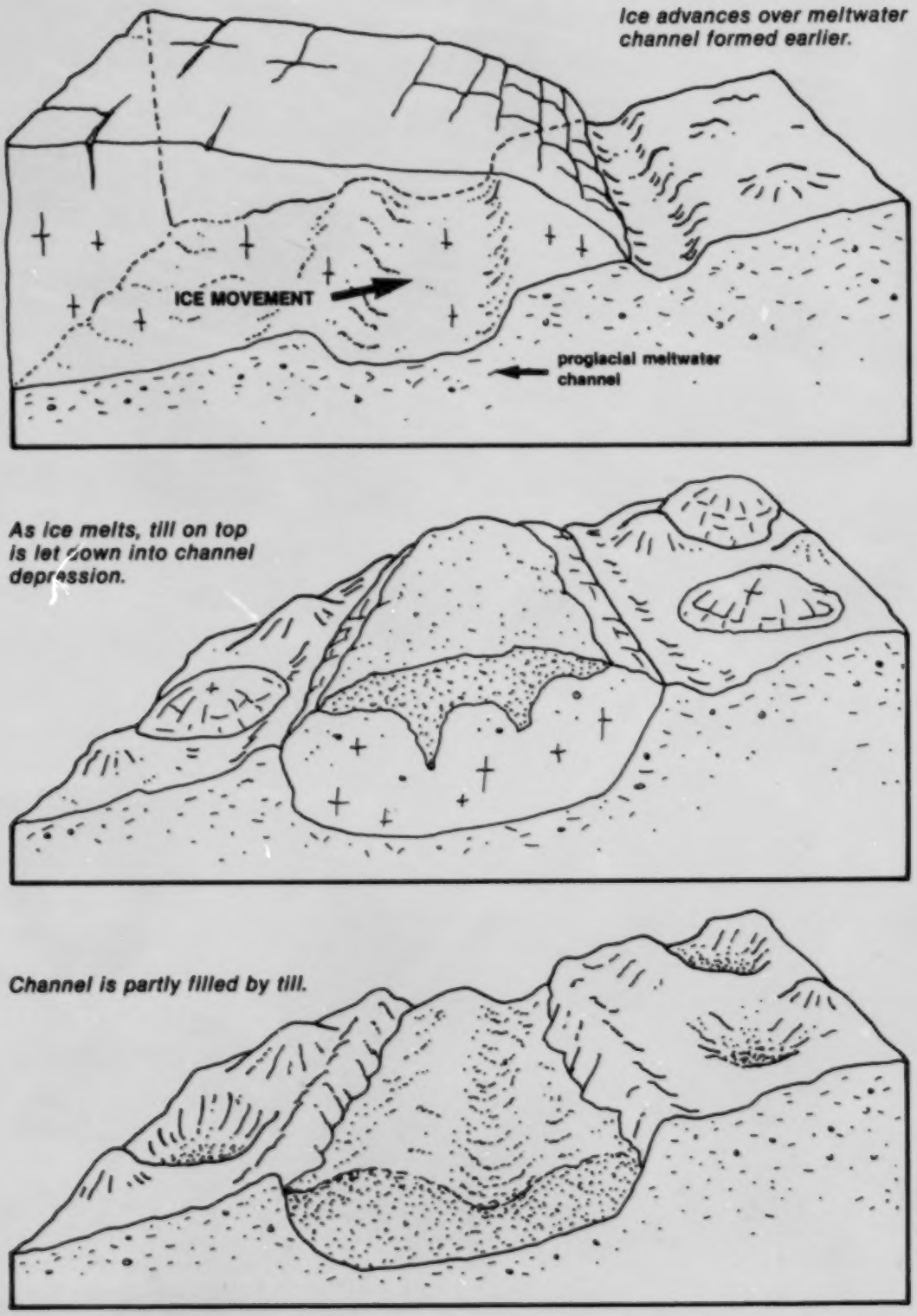

Ice advances over meltwater channel formed earlier.
ICE MOVEMENT
proglacial meltwater channel
As ice melts, till on top is let down into channel depression.
Channel is partly filled by till.

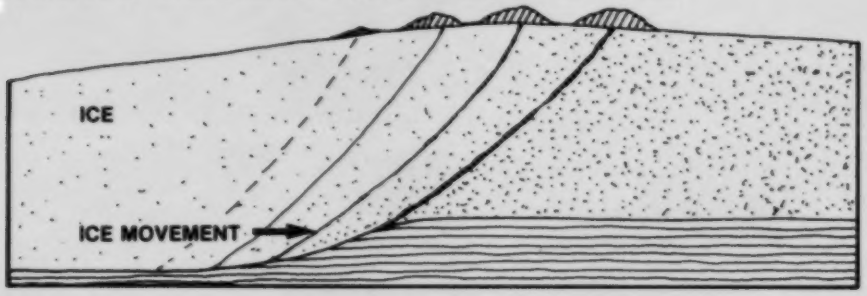
Figure 20 - Formation of a Partly-filled Valley

(2) Hummocky Moraine

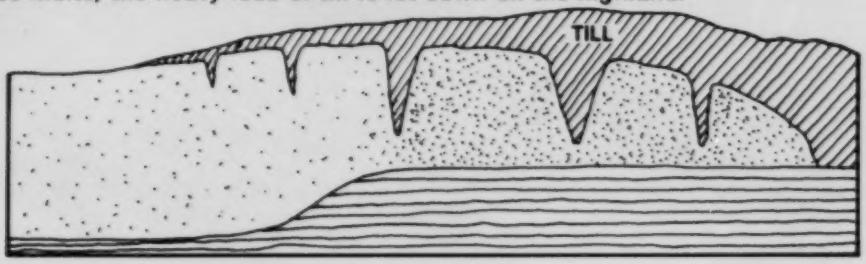
The eroding power of glaciers increases as they move up steep hills and escarpments. As a result, the ice that advanced up and over the province's highlands carried huge loads of till (Figure 21). In contrast to adjacent lowlands where the glacier ice is thought to have been relatively clean, those parts of the ice cap that melted on the Touchwood Hills and Moose Mountain, for example, were exceedingly "dirty". They let down very thick blankets of rough, hummocky moraine.

Figure 21 - Formation of Hummocky Moraine

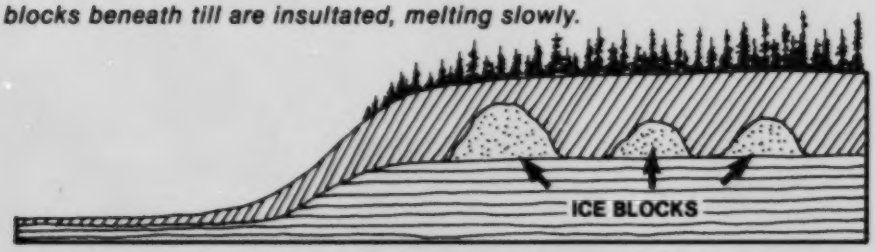
1. *Ice advances over a preglacial highland, eroding heavily as it ascends the slopes. Debris moves up shear planes, accumulates in and on the ice.*



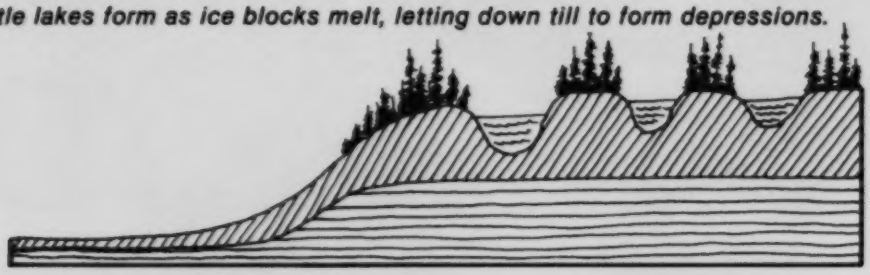
2. *As ice melts, the heavy load of till is let down on the highland.*



3. *Ice blocks beneath till are insultated, melting slowly.*



4. *Kettle lakes form as ice blocks melt, letting down till to form depressions.*



In such areas, the thick till covering slowed the melting of the ice beneath. There is good evidence that dead ice lasted under the insulating moraine on uplands for 2000 to 3000 years longer than on the neighbouring thin-tilled lowlands. Spruce forests developed on the soil over the buried ice blocks, and some were swallowed up when caverns opened below them as ice chunks melted. It is not unusual to find spruce trunks buried deep in hummocky moraine when wells are dug.

The ratio of meltwater to till was low in the last stages of deposition, because the ice was almost gone. While very wet till might "flow" like mud, till deposited later was dry, and it maintained a high relief, from 8 metres to as much as 46 metres (25 to 150 ft.). Slopes were steep, as much as 10 degrees or more. The resulting rolling or hilly topography is commonly described as "knob-and-kettle", the knobs being dry till or gravel hills and the kettles the wet depressions between.

Among the knobs and kettles, hummocky moraine usually shows some of the other characteristic forms associated with dead ice, such as rimmed kettles and crevasse-fill ridges. More distinctive, however, are occasional flat areas called "moraine plateaux", sometimes large enough to provide good farmland. They are in sharp contrast to the surrounding rough terrain. These represent the bottom sediments of lakes that formed within the decaying glacier, the water confined by surrounding walls of ice. The sediments settled as a unit as the dead ice melted (Figure 22).

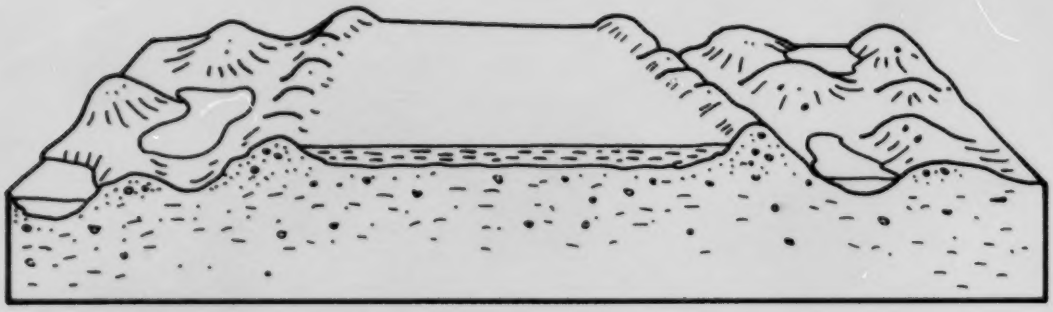


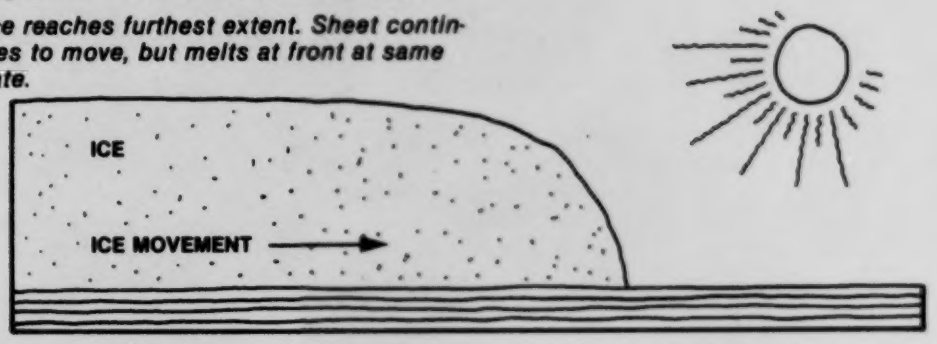
Figure 22 - A Moraine Lake Plateau

(3) End Moraine

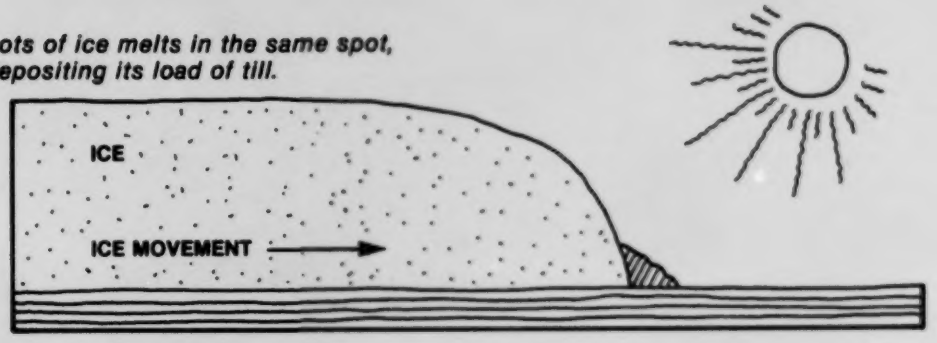
In places where a lobe of the glacier "stood still" for considerable periods of time, with the rate of melting back just about balancing the forward motion of the flowing ice, end moraines (frontal moraines) were formed (Figure 23). It has recently been suggested that the same process on uplands, with ice inflow balanced by downmelting, may have contributed to the great thickness of some hummocky moraine deposits.

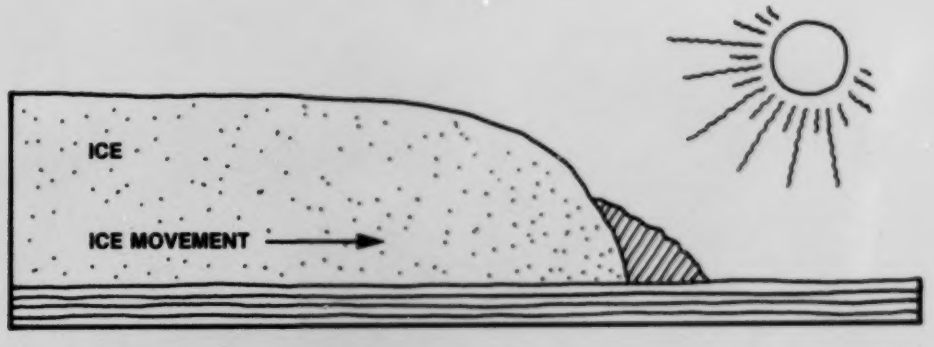
Figure 23 - Formation of an End Moraine

1. *Ice reaches furthest extent. Sheet continues to move, but melts at front at same rate.*

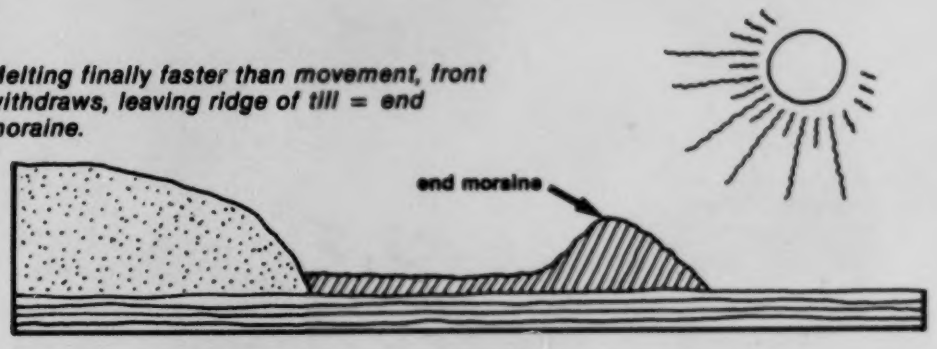


2. *Lots of ice melts in the same spot, depositing its load of till.*





3. *Melting finally faster than movement, front withdraws, leaving ridge of till = end moraine.*



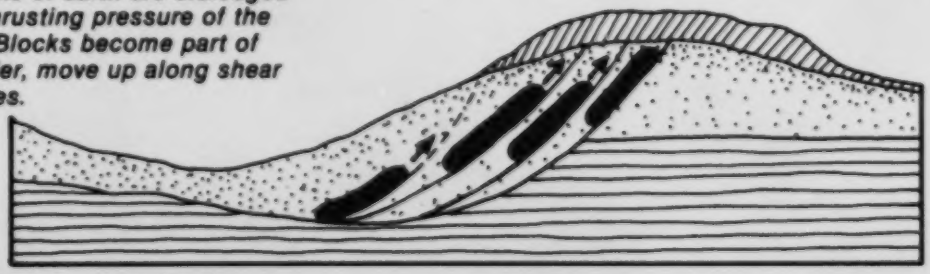
End moraines can be striking topographic features, rising up to 61m (200 ft.) above the adjacent terrain as a long narrow ridge or series of ridges with a distinctive lobe-like curvature that traces the former ice margin. In some places their relief may have been accentuated by brief forward movements of the ice edge, each forward advance shoving till into the moraine like a bulldozer ("push moraine"). Spectacular parallel sharpcrested ridges were pushed up along the northeast slope of the Missouri Coteau where the glacier seems to have dislodged blocks of bedrock and thrust them over one another like shingles. Such "ice-thrust ridges" were formed near the margins of glaciers, making them a type of end moraine.

Because end moraines occupy positions that were close to melting ice for long periods, the effects of abundant water are often evident. Frequently, end moraines are near valleys of rivers that carried meltwater away. Some of these ran along the edge of the ice, and are called ice-marginal channels. As a result of washing action of running water, fine silt and clay particles were carried away, leaving deposits of coarse sand and gravel as hills ("kames"), ridges ("eskers") and flats ("outwash plains"), either in the moraine or beside it. Indeed some moraines contain more sand and gravel than till and are called "kame moraines". A further complication is that end moraines were frequently overridden by a final forward movement of the ice which then stagnated and melted. Thus the various disintegration forms of dead-ice ground moraine and hummocky moraine, including rimmed kettles and linear ridges, can often be found draped over the top of the typical ridge-and-furrow pattern of end moraines.

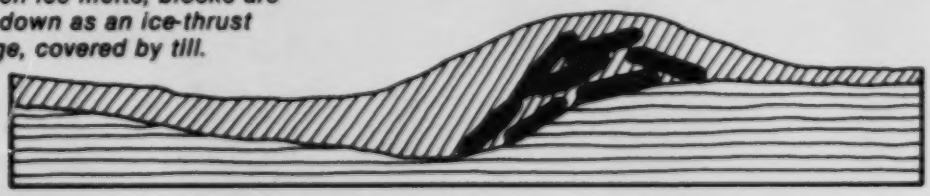
Figure 24a - Formation of Ice-thrust Moraine

As ice moves up a preglacial highland, shear planes form. Sections of ice slip over each other. Ice exerts great pressure on the bedrock slope.

Blocks of earth are dislodged by thrusting pressure of the ice. Blocks become part of glacier, move up along shear planes.



When ice melts, blocks are let down as an ice-thrust ridge, covered by till.



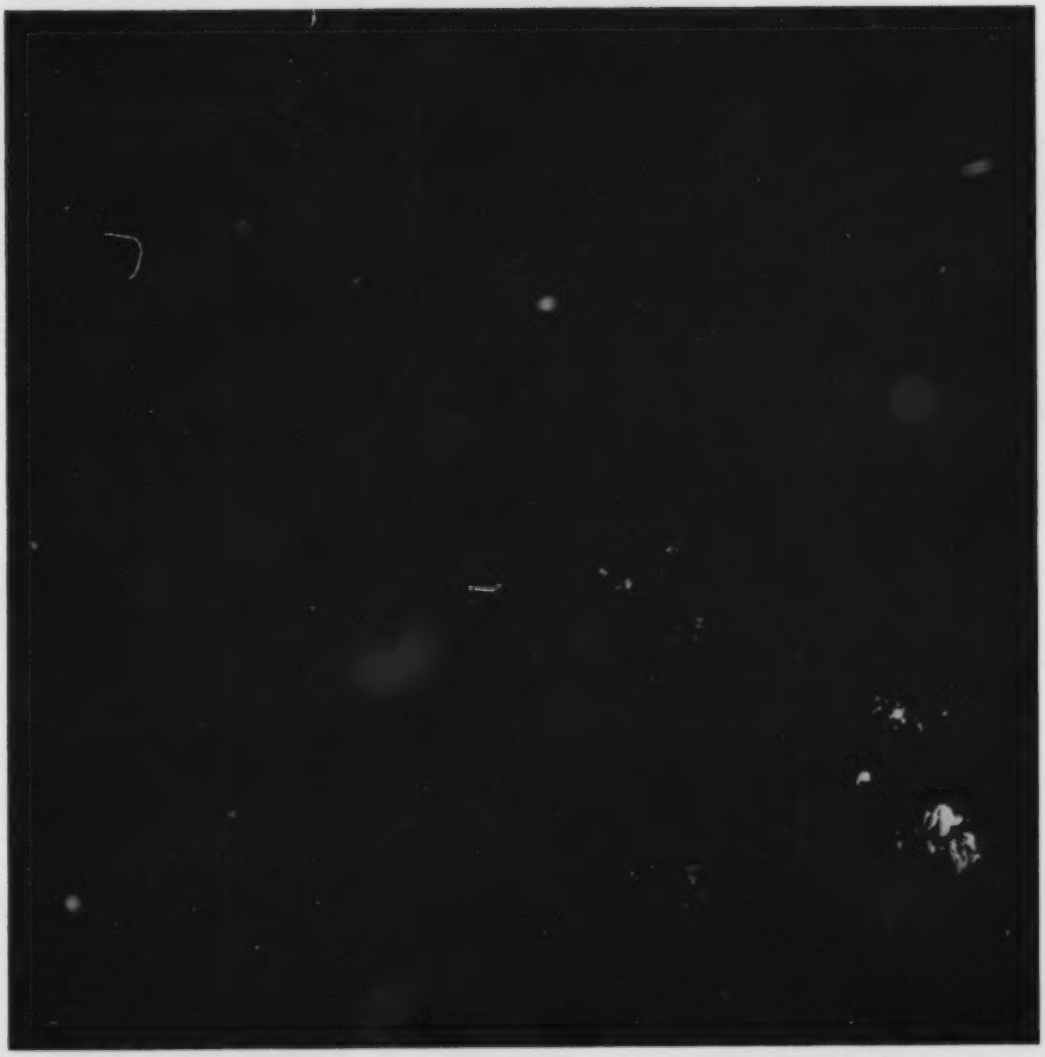


Figure 24b - Aerial Photograph of Ice-thrust Ridges in Missouri Coteau Southwest of Moose Jaw.

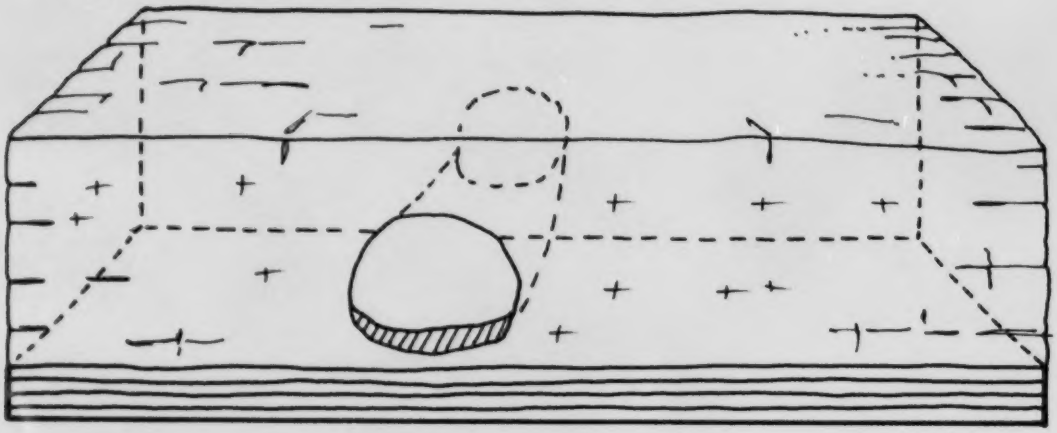
(4) Eskers and Kames

The glacial landforms that took shape close against the ice differ from till in that meltwater had a lot to do with their formation. Fine materials (silt and clay) were washed away and the remaining coarser sand and gravel were roughly sorted into layers as they were deposited. Today such deposits are often developed as gravel pits.

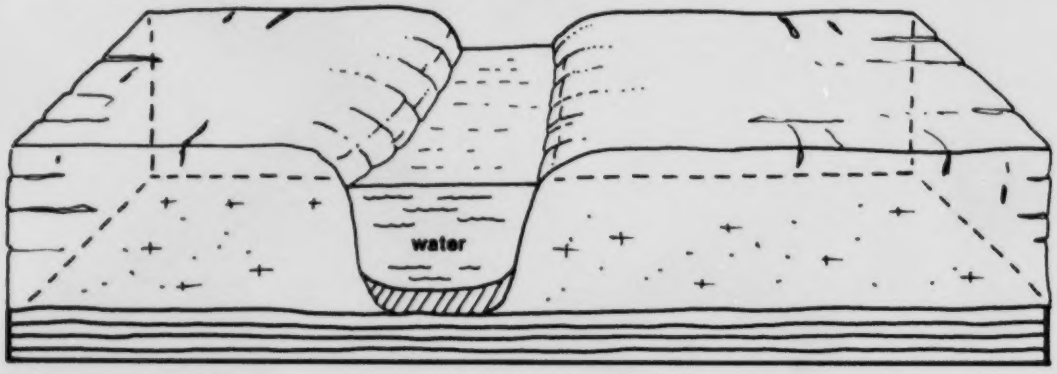
Eskers are snake-like ridges that mark the former beds of streams which flowed through cracks or tunnels in the ice. Usually, eskers are composed of sand and gravel though some have a thin covering of till that was probably deposited when the tunnel roof or the sides of the crack collapsed (Figure 25). Eskers are rare in southern Saskatchewan except just north of Last Mountain Lake. However, they are very common in the north, winding through the forests like high railway embankments, usually with game trails along the dry summits.

Figure 25 - Formation of an Esker

1. Meltwater forms a tunnel within the glacier following fractures and weak zones. Sand and gravel accumulate on stream bed.



2. Melting eventually results in open, ice-walled channels.

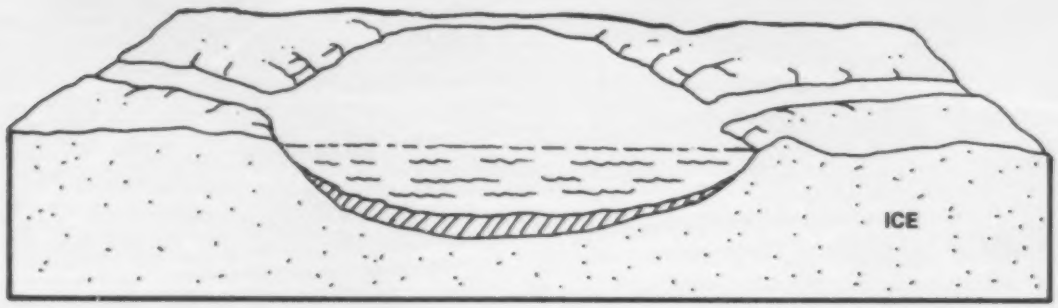


3. When ice melts totally, stream-bed sediments are left as a snake-like ridge.

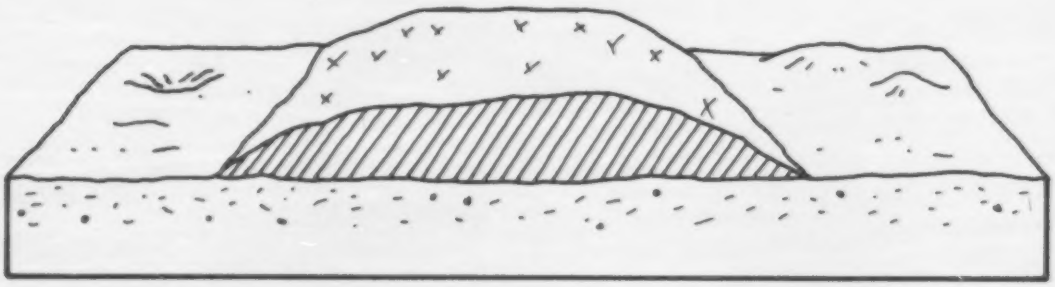
Kames, like eskers, are composed of roughly sorted coarse materials laid down by water in close association with glacial ice. They are mounded or irregular in shape, and represent the deposits that accumulate in lakes, ponds, or depressions on the ice surface (Figure 26). Cone-shaped hills up to 15 metres (50 ft.) high are a common form, their steep sides resulting from collapse of the ice against which they had been deposited.

Figure 26 - Formation of a Kame

1. Water accumulates in a depression atop the glacier. Coarse sediments are accumulated - carried into the depression by meltwater.



2. When ice melts, sediments are lowered as an irregular mound.



Kames are often associated with eskers, occasionally like beads on a string. Together they may form complex ridged, knobby landforms that mark notches between adjacent ice lobes, where much meltwater was released and a great deal of washing and sorting of till took place. As previously mentioned, kames occur here and there in hummocky moraine where, in form, they are difficult to distinguish from till knobs.

5. Proglacial Landforms

During the retreat of the glacier, many of the landforms that emerged from under the ice were subjected to washing, scouring, and sculpturing by meltwater. The result was a number of proglacial (in front of the glacier) landforms derived from moraine or superimposed on it. In contrast to the unlayered glacial till deposited directly by the ice, proglacial deposits are characteristically layered due to the sorting action of moving water. The general term **stratified drift** is applied to these sorted, layered deposits.

(1) Glacial Lake Basins (Lacustrine plains)

In Saskatchewan, the glacier's withdrawal was usually in a downslope direction since the bedrock surface falls off to the north. In such a situation, lakes formed against the ice barrier. Much of the province south of the Churchill River was inundated up to the 730 metre (2400 ft.) contour by lakes that existed for short or long periods and that disappeared or shrank to present-day size when the retreating ice uncovered corridors low enough to drain them. Saskatoon, Regina, Moose Jaw, North Battleford, Prince Albert and most of the province's large towns are on or near the fertile plains of old glacial lake bottoms.

As material was washed into the proglacial lakes and moved around by offshore currents, it was sorted into sand, silt and clay. Particles of mineral matter settle out of water at rates proportional to their size, so the larger ones (fine gravel and sand) fell to the bottom near the lake shores while the finer ones were transported toward the deeper basin centres. Silt-sized particles (see Figure 14) usually settled in the shallower waters while clay-sized particles accumulated in deeper waters. Because even the slight underwater currents produced by surface waves are sufficient to keep fine mineral particles in suspension, much of the silt and clay settlement took place in winter when lake surfaces were frozen and the waters were comparatively still. As a result, there were alternating layers of coarse (summer) sediments and fine (winter) sediments. Each pair of layers is called a "varve" (Figure 27), and represents one year of sedimentation. Some believe that they can be counted to estimate how long the upward "growth" of various lake bottoms went on, just as the age of a tree can be estimated by counting the annual growth rings. The topography of lake bottoms reflects the topography of underlying deposits, although there must be some smoothing and levelling of features as a result of wave-washing and accumulation of sediments in hollows. Many of our glacial lake beds are extremely level, hence the name "lacustrine plain". Where lakes inundated rough terrain for a short period of time, the lake sediments were draped like a blanket over underlying features. In some situations, the lakes formed partially over shelves of "dead" ice, and sediments accumulated on top of the ice. When this subsequently melted, the sediments were let down unevenly, resulting in uneven lake-bottom deposits. Varves in such locations are often folded and contorted.

Along the ice-free margins of proglacial lakes, where the slope of the shoreline and the surface materials were suitable, wave action created curving beach-ridges of sand and gravel. On very shallow, sloping shores the force of the waves was probably lost in reed beds and no beaches were formed. On rolling terrain the hillsides were notched by wave erosion, resulting in cliffs fronted by stony terraces. Such lake-edge landforms — called collectively "strand lines" — are rather rare in southern Saskatchewan.

Figure 27 - Varves
Varves revealed in a road cut through sediments of Glacial Lake Indian Head.

(2) Outwash Plains and Deltas

Just as meltwater within ice-walled channels deposited sand and gravel as kames and eskers, so meltwater flowing beyond the ice margins also laid down distinctive deposits. They are generally more level, better sorted, and layered beds of material — called stratified drift. They are mixtures of material, but differ from till in being roughly layered.

Deposition was as fans or aprons bordering the ice, as bars or terraces down the sides of larger meltwater stream valleys, and as deltas where such streams entered lakes and dropped their sediment loads. Because of the complex histories of meltwater streams and lakes, which frequently changed shape or filled and drained several times, the different kinds of meltwater deposits are sometimes lumped as "glacio-fluvial" (glacial + stream) deposits, or classed as "fluvio-lacustrine" (stream + lake) plains.

Most meltwater sediments, called outwash, are relatively flat-surfaced. Exceptions occur where the sediments were deposited around or atop disintegrating ice. Then the sands and gravels were "let down" unevenly as the ice melted, to produce a hummocky or kettled surface ("pitted outwash"). On air photos the surface of outwash may also show a faint pattern of current scars, indicating deposition by fast-flowing heavily loaded streams. It is characteristic of outwash that the coarser gravels are found near the glacier source where stream gradients were high. Stream velocity and carrying power were also high as a result, so all but the coarsest particles were carried off. The finer sands were deposited further away as gradient, when velocity and carrying power lessened. Similarly, in outwash beds there is often a gradation in particle size from large at the bottom to small at the top. Streams were swift when the first materials were laid down, but became sluggish as the beds built up and reduced the gradient. Outwash plains are therefore valuable sources of clean, sorted sand and gravel. They are also excellent construction sites and contain good supplies of groundwater.

(3) Eroded Till Plains

When shifts in the position of ice barriers suddenly released large volumes of water from glacial lakes, the downstream terrain was scoured by massive floods. The water quickly cut through stratified drift to the surface of the till landforms beneath and, by washing away the fine materials, concentrated stones and boulders on the surface. Erosion by waves also produced stony till at the margins of some lake basins. In both cases the finer materials washed out of the till were deposited elsewhere as stratified drift.

The boulder-studded surfaces of eroded till plains are a fairly common feature throughout the province (Figure 28). They are often associated with the valley and coulee systems discussed next.

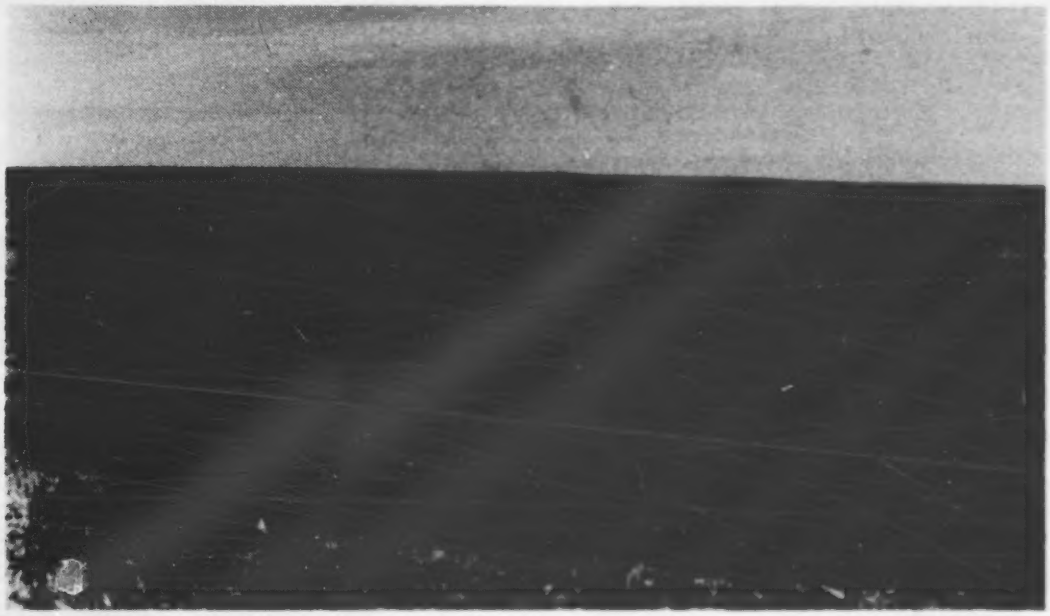


Figure 28 - Eroded Till Plain

This eroded till plain alongside the Arm River Valley near Findlater is strewn with boulders.

(4) Meltwater Channels and Spillways

Meltwater channels carried water away from the glacier. Spillways were the drainage outlets of proglacial lakes. Both are similar although some spillways carried a larger flow over a longer time than meltwater channels and so were cut wider and deeper, even into bedrock. Mostly the channels are occupied today by relatively small "underfit" streams, although the large South Saskatchewan River occupies some segments of old spillways.

Meltwater channels are of variable size. Some are moderately wide (300 metres, or so) but shallow (3 - 6 metres) so that the valley walls are gently sloping. Intermittent streams connecting chains of sloughs, and occasional patches of sand and gravel (kames or outwash), are usual in them. Larger meltwater channels (800 metres wide, up to 60 metres deep) formed under the influence of abundant meltwater. An example would be right beside the ice where drainage downslope paralleled the glacier's edge. Much of the Qu'Appelle Valley formed in this way. Such "ice-marginal channels" are typically found bordering end moraines and, where the ice margin lay along a slope, they were cut in a "side hill" position.

The largest valleys are usually proglacial spillways, some of them as much as 100 metres deep and 2 kilometres or more in width. The Qu'Appelle Valley, Little Manitou - Last Mountain Lake, and Blackstrap Coulee are well-known spillways in southern Saskatchewan. Once they carried great rivers. The rush of water in such drainageways scoured the marginal till on each side, producing bouldery "benches" and valley slopes. Farther downstream, materials from the eroded till were dropped, along with outwash, as sand and gravel terraces bordering the valley margins. Landforms in spillways and channels have been much modified in postglacial times as discussed later under postglacial landforms.

6. Influence of Relief on Glacial and Proglacial Landforms

In the preceding sections on glacial and proglacial landforms the effects of differences in elevation (relief) have frequently been mentioned. On lowlands, the leveller forms of till and sorted drift were deposited while on uplands the hilly or ridged moraine was more usual. The reasons relate to the interactions of glaciers with the physical landscape they encountered. Approaching uplands, the moving ice eroded and steepened slopes, thrust up ridges of drift and bedrock along the edges, and deposited blankets of hummocky moraine at the tops. By contrast, in the lowlands the glaciers tended to smooth the surfaces, levelling off the rises and filling the valleys. The proglacial lakes that formed south of the advancing or retreating ice also occupied the lowlands, continuing the smoothing process. For these reasons the major physiographic divisions of the province, characterized by differences in relief, often bear distinctive topographic patterns of glacial and proglacial landforms.

The behaviour of the glaciers was not haphazard. Like other natural processes they also acted according to environmental rules, not all of which are yet understood. The many excellent examples of glacially created forms in every part of Saskatchewan make it an exceptional laboratory for students of nature.

7. Postglacial and Residual Landforms

The last ice sheet withdrew from the Saskatchewan area about 20,000 years B.P. (before present) in the south, 10,000 years centrally and 8,000 years in the extreme north. Since then, the effects of wind, water and gravity have continued to mould the land surface. Over much of the area the glacial and proglacial landforms have not been greatly changed. The dry Saskatchewan climate with its six months of snow-covered, frozen soils is not conducive to rapid or extensive erosion and deposition. However, several "new" postglacial landforms have appeared, and there are also a few of interest that came through the glacial period without much change — the "residual" bedrock landforms. Surface water bodies and groundwater are not strictly postglacial or residual features but they are also mentioned because of their close alliance with the present forms and structures of landscapes.

(1) Dunes and Loess Sheets

Wherever mineral soils are dry and unprotected by vegetation, winds can erode them. Clays and silts tend to resist drifting because the small particles hold moisture, and stick together. Sometimes when clay has aggregated into larger, sand-sized lumps they can be moved by wind. Sand is relatively mobile, so when the ice uncovered sandy-silty till — or more importantly when rivers and lakes receded and exposed alluvial flats, outwash and sandy shore deposits — the winds began to winnow the surfaces. It is likely that maximum erosion and deposition by wind took place in early postglacial time when the climate was warm and dry, perhaps before the perennial types of plants that stabilize the soil had migrated into Saskatchewan.

Figure 29 - Athabasca Sand Dunes

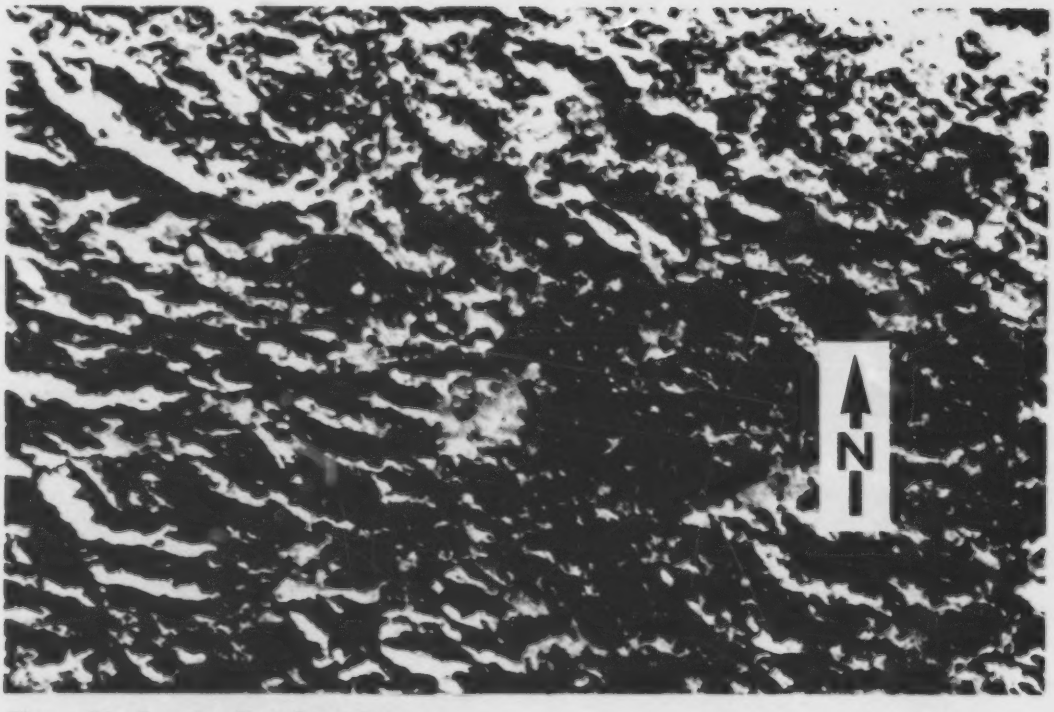


Figure 30 - Douglas Park Sand Dunes
Sand dune ridges parallel to the prevailing northwest wind at Douglas Provincial Park.

Gravel and coarse sand are too heavy to move readily but medium-textured sands were shaped into dunes, the most spectacular being those that extend for miles along the south shore of Lake Athabasca, "The Sahara of the North" (Figure 29). In the south too there are intriguing dune areas north of Prince Albert, south of Saskatoon, at Douglas Park on the Qu'Appelle arm of Diefenbaker Lake, and north of Maple Creek in the Great Sand Hills. The dunes are now mostly vegetated, although open drifting sand hills and "blowouts" are common. The winds that shaped dune fields blew mostly from the west and northwest, so the patterns of ridges and hollows are similarly aligned. The most common dune form is "parabolic" or U-shaped, with the open side toward the prevailing wind. Other dune forms are slightly crescentric, parallel to the wind (Figure 30) or hummocky.

At the same time as the dunes were forming, there must have been occasional great dust storms as the finer materials were winnowed out of the coarser. Sheets of very fine sands and silt aggregates accumulated downwind from erodable surfaces, perhaps trapped by the cover of early arriving plants. The material is called **loess** and it is characteristically stone-free, calcareous (high in calcium-carbonate content) and without distinct layering in profile. It can occur as a blanket over most other landforms, for its deposition is a function of wind direction rather than topography. For example, the high plateau of the Cypress Hills is in many places covered with several feet of loess.

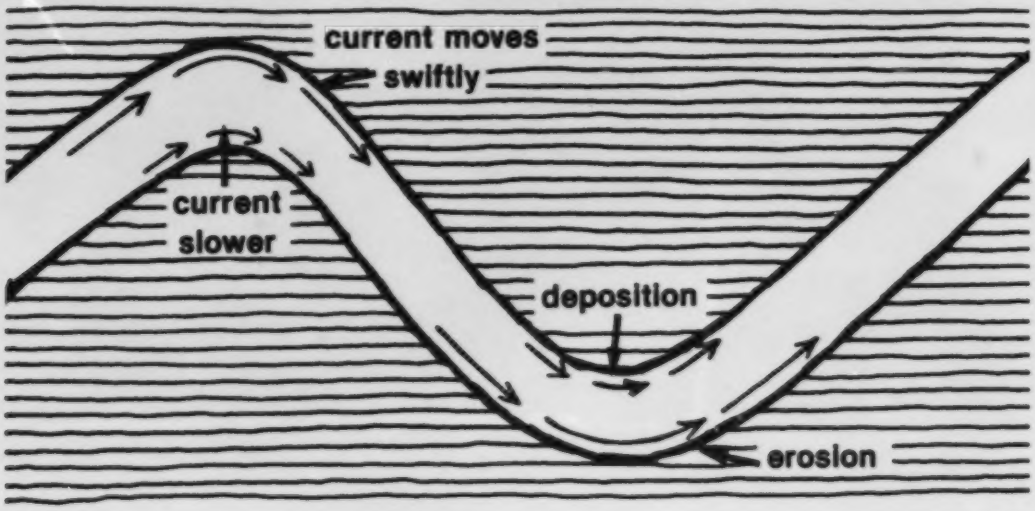
(2) Flood Plains and Valley Features

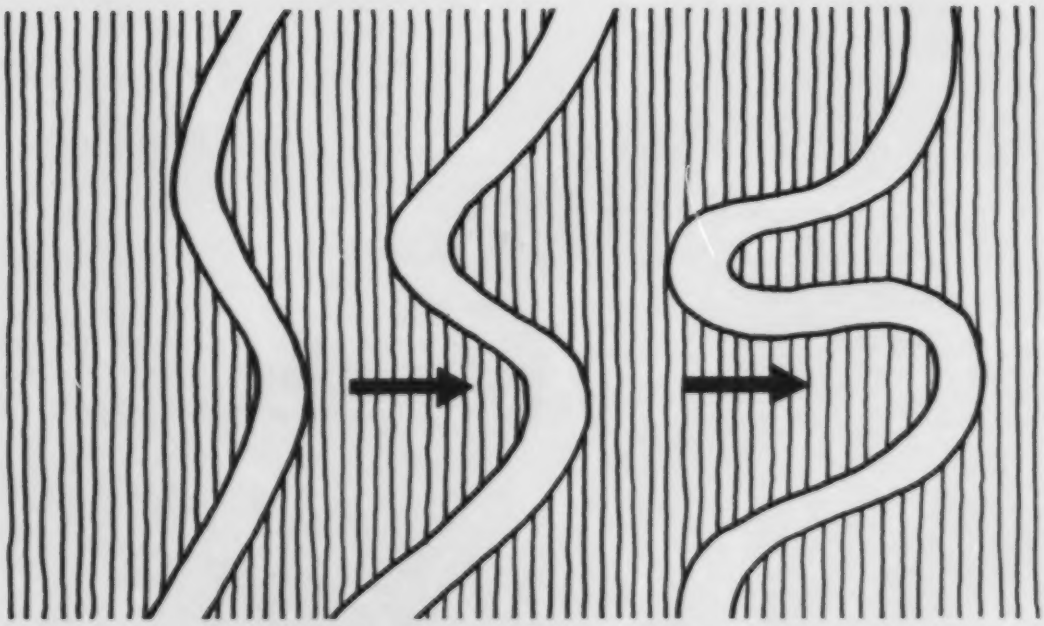
Every river and stream works to reduce the surface of the land toward sea level, at first cutting down to form a channel and then paring back the banks on either side of it. Such lateral erosion flattens off the valley bottom and establishes a "flood plain". When the river basin is full, during spring snow-melt, the flood plain is covered by muddy water from which sediments settle to build up and level the flood plain. But meanwhile, in the active channel, there is a sideways erosion that cuts away the flood plain on the outside of curves. The eroded material is deposited downstream, where the current slows on the inside of curves. This results in ever-exaggerating curves, or meanders, in the channel and frequent changes in channel location (Figure 31). The material deposited is called "alluvium" and, because it is deposited by running streams, it is described as "fluvial" in origin.

There are a number of minor landforms associated with flood plains (Figure 32). **Channel bars** are low islands in mid-stream. **Meander scrolls** or **point bar deposits** are parallel curved ridges and troughs formed on the inside of stream meanders as they migrate horizontally. **Levees** are channel-side ridges that are built up where floodwaters drop sediment as they overtop the channel banks. **Backswamps** are wet, poorly drained low areas behind the levees. **Oxbow lakes** are old channel meanders abandoned when a stream changes its course. Where rivers are deepening their channels, remnants of their former flood plains may persist at higher levels as Terraces (Figure 33).

The major coulees in the province, the proglacial spillways and meltwater channels, once carried very large rivers that began as broad, shallow drainages. As they cut deeper, more confined channels, remnants of their earlier floodplains were left on or near the valley sides. At higher levels, scoured, boulder-covered benches (eroded till plains) are common (see Figure 28). Lower in the valley there are usually old point bars, channel bars, and sand-and-gravel terraces deposited as outwash or valley trains.

In rounding a bend, the water at the outside of the current must move faster because it must travel further. Higher velocity means greater erosive power. Downstream, sediment-laden water slows on inside of curve, and drops its load.

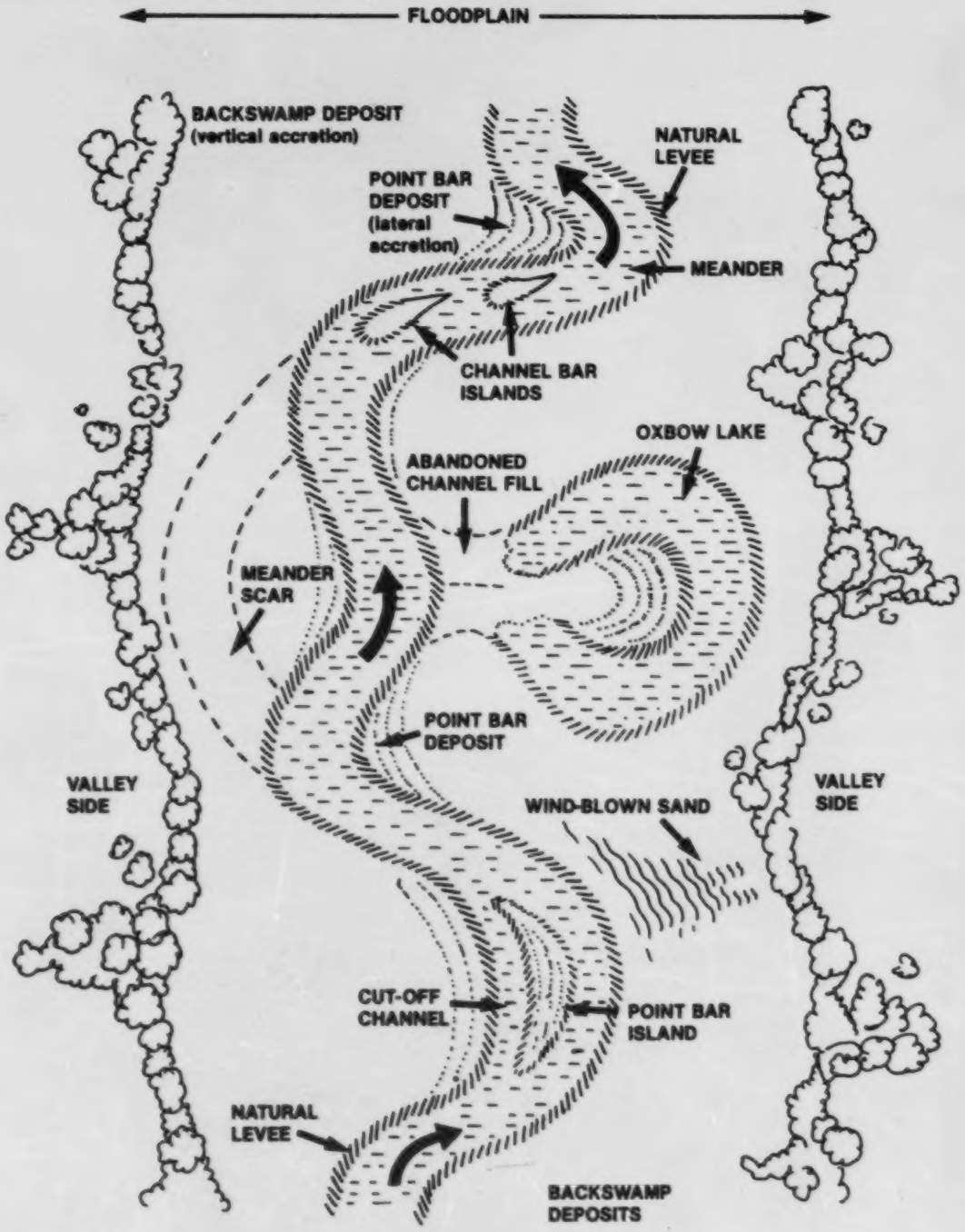


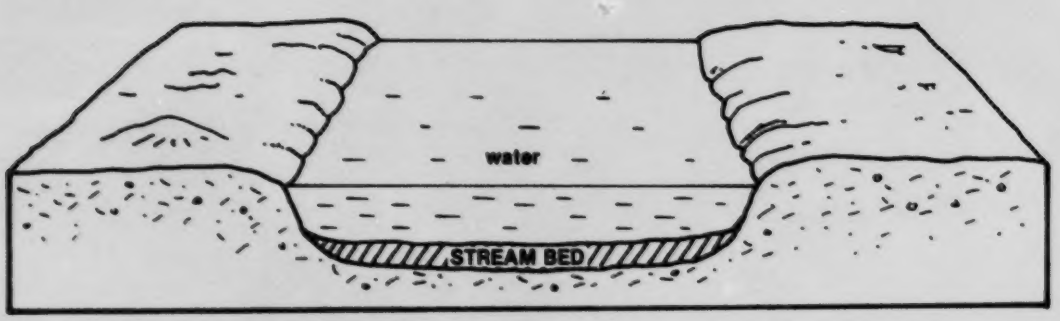


Curves become exaggerated, forming meanders.

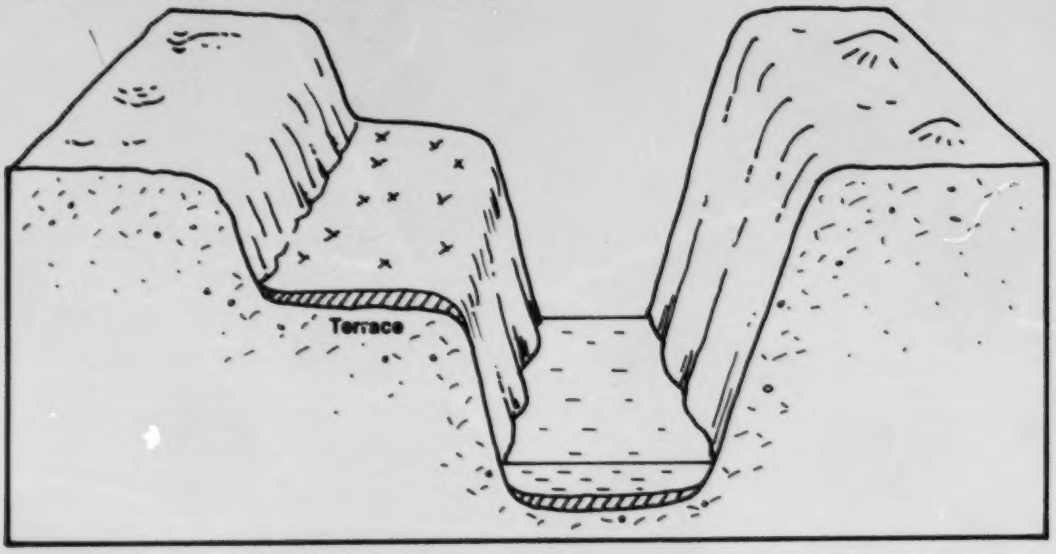
Figure 31 - Erosion and Deposition in a Stream

Figure 32 - Floodplain Features





Meltwater from glacier erodes wide channel.



Stream cutting is displaced to one side and continues to deepen valley. Unused portion of earlier channel bottom remains as a terrace.

Figure 33 - Formation of a Valley Terrace

Today most coulees are occupied by "underfit" streams that are much smaller than those that carved the valley in the first place. The modern flood plains, correspondingly small, are frequently established on top of very deep "valley fill", or alluvium, deposited in glacial and postglacial times. For example, parts of the Qu'Appelle Valley were cut as deep as 180 metres (600 ft.) below the neighbouring plains and then refilled with 45 to 75 metres (150-250 ft.) of alluvium. In some places the filling process is continuing. Sediments brought into the coulees and valleys as wash (alluvium) from tributary channels, or by gravity creep and slump from the valley walls (colluvium), are not carried away by the small flow of the streams and therefore accumulate as "fans", which slope gently away from the foot of the valley walls. Indeed, in some places where tributary coulees enter a main valley,their gravelly alluvial fans spread across the floodplain, forcing the river to the opposite bank or even damming it to produce a lake. Fort Qu'Appelle is built on just such a fan, formed of debris carried into the Qu'Appelle Valley by Echo Creek. Many of the province's southern recreational areas are centred on water bodies formed in old spillways either by natural or by man-made dams (Diefenbaker Lake, Blackstrap, Qu'Appelle Lakes).

Interesting features develop in valley walls where they intersect more than one geological layer. There were a number of glacial and interglacial periods, during each of which there was erosion and deposition of till, stratified drift and landforms. Because of this, the unconsolidated surface deposits tend to be layered like the underlying bedrock. Each layer exposed in valley slopes has characteristics that influence surface features such as slope steepness and vegetation. Springs and seeps often occur at the line of contact between upper permeable layers (aquifers) and lower, less permeable layers. Examples are: where sand dunes overlie lake clays, where coarse outwash caps till, or where the lowest till lies on bedrock. Some exposed layers may produce very large flows of water, contributing in summer to dense marshy hillside vegetation and in winter to the build-up of thick ice sheets. These are springs.

The presence of springs can contribute significantly to valley erosion. **Piping** is a process in which a sub-surface layer, usually sand, is washed out by groundwater movement, causing the overburden to cave in. **Mudflows** or **debris flows** are occurrences in which water-saturated soil masses flow downslope. The most spectacular landslides along valleys are due to slumping, where large blocks of earth drop down from the sidewalls and move toward the valley centre. Although seepage is probably a contributing factor, these major slope failures are usually caused by stream erosion that either cuts away the base of the bank and "oversteepens" the slope, or deepens the valley below the contact zone between different geological units such as till and shale bedrock. Slippage occurs easily along such contact zones. Slump blocks give a hilly, terraced appearance to many parts of the Qu'Appelle and Saskatchewan River valleys. Such spots appear to be attractive building sites but their instability renders them unsuitable and possibly very dangerous. The weight of a large building might be all that is required to trigger additional movement of the slump block.

(3) Bedrock Outcrops and Badlands

The oldest bedrock surfaces, underlying all the province, consist of ancient Precambrian crystalline rocks. Massive formations of sedimentary bedrock have been built up on top of them, layer by layer, through the eras of geological time. They consist of limestone and dolomite, mudstone and shale, sandstone and conglomerate. Erosion has removed most of the sedimentary beds that once lay on top of the Precambrian Shield, and has stripped younger upper layers from the older, lower layers in the south.

A line from Creighton near Amisk Lake in east central Saskatchewan to the Cypress Hills in the southwest crosses younger and younger bedrock. Outcrops of bedrock occur where erosion is taking place in valleys and badlands, on escarpments and on hillslopes (see Figure 12).

North of La Ronge the Precambrian rocks are prominent, interspersed with the glacial, proglacial and postglacial landforms previously described. Knobs and ridges of hard crystalline rock characterize the rolling, glacially-scoured landscape. However, a large saucer-shaped area within the Shield, extending south from Lake Athabasca to Cree Lake, contains mostly flat-lying sandstone bedrock with gentle topography and few outcrops of crystalline rock.

A belt of limestone and dolomite of Paleozoic age (see Figure 11) bearing fossil sea shells is exposed along the edge of the Precambrian Shield. Presumably this is the source of the numerous limey stones and boulders that are scattered through the southern glacial till. But the most extensive near-surface bedrock is Cretaceous in age, consisting of shales and sandstones deposited in shallow seas on top of the Paleozoic strata. The lower Cretaceous layers appear as outcrops in the scarps and slopes of the Pasquia and Porcupine Hills. The upper members are exposed along the Missouri Coteau and in the deeper river valleys and coulees of

the south. The Badlands near Avonlea and in the Big Muddy Valley are in Cretaceous sediments.

The youngest and highest strata were laid down in Tertiary times, above the Cretaceous rocks. They cap the uplands in the Cyrpess Hills as well as the Wood Mountain highlands and eastward. Examples are the gravel beds at the "Conglomerate Cliffs" in the Cypress Hills, the Kildeer-Rockglen badlands in the driftless (unglaciated) part of the Wood Mountain highland, and the exposures containing coal-bearing seams along the Souris River near Estevan.

(4) Surface Water and Groundwater

Lakes and ponds have been formed in various ways. Obviously the glacial, proglacial and postglacial landforms exert a great influence on surface water. Hills and ridges shed precipitation which tends to accumulate in the depressions of the landscape, in basins and valleys.

The largest water bodies in the province are remnants of much larger proglacial lakes whose levels dropped when their confining ice dams melted. Some major lake basins were topographically low even before glaciation (Lake Athabasca and Old Wives Lake). Others were scooped out, at least in part, by ice activity and meltwater erosion (Little Manitou Lake and Last Mountain Lake). The lakes in the Qu'Appelle glacial spillway have been affected by the damming action of alluvial fans built into the valley by side channels. The innumerable smaller lakes and sloughs that are famous as duck habitat occupy local depressions or kettles in hummocky moraine, till plains and partly-filled meltwater channels.

The characteristics of water bodies today relate not only to the size, shape and depth of their "inherited" basins, but also to their environments. The surrounding terrain influences the quantity and quality of water and sediments feeding into them. For example, wind-blown snow, piled into hollows and trapped by fringing bushes, contributes as much as 80 percent of the run-in water of sloughs. Therefore, removing the natural "snow fence" cover so that the wind sweeps the snow away can have a local drying effect. Land uses that contribute to erosion of soil from slopes also hasten the filling in of shallow basins and the disappearance of surface water.

Not everyone realizes that the water seen at the surface is connected with the unseen groundwater, the two together forming large hydrologic systems that flow under the influence of gravity and surface evapotranspiration. Evapotranspiration is the combination of evaporation from the soil or surface water, plus the water vapour released by plants through transpiration. Depending on the position and water-carrying properties of the geologic layers, surface water may percolate down to the groundwater table or groundwater may move to the surface. It is common to find a flow of groundwater from highlands (recharge areas) to spring outlets on adjacent lowlands (discharge areas). When the conducting layers are permeable sand and gravel, substantial amounts of water are moved in this way.

The subsurface water-saturated layers that can be tapped with wells are called "aquifers". Some of the large aquifers actually have lakes perched on their tops, as in the Qu'Appelle Valley. Maps produced by the Saskatchewan Research Council for the south of the province show the locations, depths and characteristics of water-bearing strata. Buried valleys and buried basins are often good sources of fresh water, especially when they contain thick beds of sand and gravel. Deeper down the underlying bedrock marine shales usually yield poor-quality salty water, while the non-marine beds yield good-quality water. At shallower depths, sands and gravels in or between till sheets produce useable water in quantities proportion to their thickness and extent.

The surface water that feeds lakes directly from precipitation is low in dissolved substances unless it has fallen through the smog of cities or the smoke of industrial plants. Groundwater can be rich in dissolved substances, depending on the geologic and organic materials through which it has percolated. Seepage through glacial till that contains limestone makes the water "hard" due to the solution of calcium and magnesium carbonates and bicarbonates. A high iron content can be picked up from subsurface layers in the same way. Percolation through fertile tilled soils and through concentrated organic matter such as manure piles enriches groundwater with nitrates — a potential health problem in some shallow farm wells and stock-watering ponds. Of considerable ecological importance are the sea-water salts — sodium-sulfate, magnesium sulfate and sodium chloride — which enter the groundwater from the marine bedrock that underlies a large part of southern Saskatchewan. Some salts are also dissolved from glacial till that contains material that the glaciers picked up from marine shales. These are the salts that, in dry weather, appear as a white crust (misnamed "alkali") in and around springs, ponds and shallow lakes — a sure sign that the waters are saline.

A comparison of saline and non-saline sloughs illustrates the important balance between what comes into a slough from precipitation, run-off, and groundwater; and what goes out through overflow or evaporation. Sometimes the two types of slough can be found side by side. Saline conditions indicate a discharge (net in-flow) area, and freshwater conditions indicate a recharge (net out-flow) area.

In other words, saline sloughs occupy receiving basins with little flushing action by overflow, so that most water loss is by evaporation. The result is a gradual concentration of sodium and magnesium salts brought in by overland flow in streams or by the discharge of groundwater. Examples of large saline lakes in closed basins are Redberry Lake, Manitou Lake and the Quill Lakes.

The Last Mountain Lake lowland is an example of an area receiving saline groundwater either by upward leakage from the underlying bedrock or by discharge from the neighbouring Allan Hills and Touchwood Hills. Little Manitou Lake is one of the most saline water bodies in the province. It is nearly four times as salty as sea water, and supports only a few plants and one animal, a brine shrimp.

IV. Interrelationships of Landforms, Climate, Vegetation, Animals, Soils

1. Introduction

Landforms are the foundations of landscapes. The preceding survey of common Saskatchewan landforms therefore provides a fundamental introduction to the living systems that are built on them. It is the purpose of this section to show how the development of landforms, climates, vegetations, animal communities and soils have gone on simultaneously, by processes of mutual adjustment, to form the living landscapes that are our immediate environments.

Remember again that our analytic minds have a tendency to take things apart. Particularly with systems larger than organisms, we have difficulty in perceiving them as integrated things in nature. Instead of sensing landscape ecosystems we almost automatically interpret objects around us such as plants, rain and snow, soils, animals, people, as separate and unrelated phenomena. In other words, organisms immersed in their environments do not necessarily see their surroundings for what they are. A thoughtful fish might never think that all around it lay the sea, until a flying fish *who had been outside* reported the existence of the aquatic ecosystem. Just so the astronauts, seeing the world from outer space, brought back to us pictures and descriptions confirming the organic character of the biosphere. Only then did it hit home: here we are, immersed in and sharing a life-support system on a big blue marble floating through black space. Enough is now known of the earth's self-renewing processes to demonstrate the close connection of things not previously accepted by common sense as parts of a larger whole. As one example, the cycles of water, carbon and oxygen enter into and bind together the worldwide atmosphere, seas, continents and all living things.

For purposes of study the biosphere can be divided into subareas such as the continents where variations in the interactions of atmospheric climate, geology, relief and organisms produce various regional landscapes: tundra, temperate forest, grassland, desert, tropical forest. In further divisions and subdivisions down to the local level, parallel relationships between climate, landforms, water bodies, soils and communities of plants and animals interact mutually to produce the landscapes around us.

Recognition of similar ecological relationships at all geographic scales from small to large supports the idea that the world, the biosphere, can itself be realistically conceived as sets and subsets of smaller ecological systems. There are ecosystems within ecosystems within ecosystems, all contributing as parts to still larger parts up to the inclusive biosphere. From this viewpoint, an understanding of "how the world works" requires attention to many levels. Much can be learned through study of the whole province, or of the parkland region in the province, or of an area of hilly terrain in the parkland region, or of a single slough or grassy slope in the hilly terrain. No landscape of whatever size is inconsequential.

2. Life Zones or Regional Landscapes

Pictures of Saskatchewan taken from satellites miles above the earth reveal a number of major landscape divisions. Visible in the southwest is the grassland region, cut through by the South Saskatchewan River, and enclosing the Cypress Hills as a wooded "island". From the Missouri Coteau northeastward a broad band of agricultural land appears as a checkerboard of tilled fields, stretching to the North Saskatchewan River. Beyond, the terrain darkens as mixed forests increase and agricultural lands decrease. Another change takes place near Lac La Ronge where Precambrian bedrock comes to the surface, covered mostly with evergreen trees and dotted with lakes.

If one looks carefully, other large landscape types are also visible. The great area of pine-covered sand south of Lake Athabasca, and the open "savanna" woodlands of the northeast corner are examples.

What makes the pattern visible? There is no simple answer. It is due to the interplay of geology, relief or elevation, topography, climate, vegetation, soil, settlement and land use. Rarely, if ever, can a single factor be picked out as most important. Because these are ecological units of land, they are regional landscapes or, in terms of biological environment, "Life Zones". They tend to grade into one another because nature rarely provides clear boundaries. Only locally can fairly sharp dividing lines be seen, usually where there are abrupt changes in landform (topography and geology) and in land use.

For these reasons, deciding how many Life Zones there are and mapping them is to some extent a matter of personal preference. It might be thought that a good objective map could be prepared by plotting the coinciding boundaries of the landscape components: the landforms, climates, soils, vegetation and animal distributions, including man. This idea becomes more believable when one sees the many published maps of landscape components which do show common boundaries (Figure 34). However, it should be remembered that mappers frequently have to rely on each other's work, so that some climatic lines are drawn from vegetation maps, some vegetation boundaries from soil maps, some soil boundaries from landform maps, and so on. We have reason to be a little sceptical when comparing the close fit of various geographic maps!

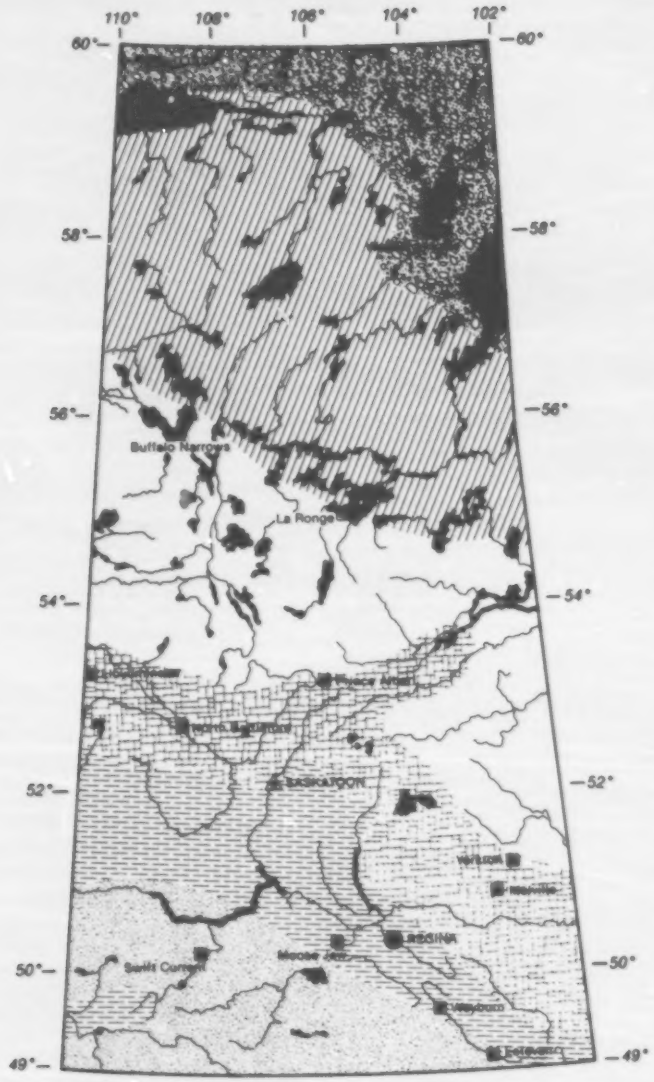
The reason why boundary coincidences ought *not* to be expected is that many of the landscape components, though related, are not static. They are constantly changing and adjusting to one another at different rates. Weather changes can be rapid, from year to year or in longer climatic cycles, while the consequent adjustment of vegetation and soil lags behind. For example, settlement of the western plains virtually stopped wild fires; in effect man caused a change in one important aspect of the year-to-year weather. This allowed aspen groves to expand over large areas and form a "parkland" belt that, according to the evidence in its dark soils, must have existed for a long time as grassland. Today these grassland soils under forest, slow to adjust to the new environment, are somewhat mismatched to their native vegetation cover though admirably matched to the cereal crops introduced after land clearing. In a similar way, neither vegetation nor animal communities necessarily reflect by their distributions the current regimes of climate. In short, a vegetation map is not a climatic map, nor is a soil map an animal habitat map.

There is no final solution to this problem of ecological boundaries for it is in their nature to be vague and fluctuating. Where interrelationships and continuing adjustments are essential, boundaries are bound to be vague. We map landscape ecosystems because it suits our purposes, not because there are well-defined units that cry out for recognition. If we accept this approach, it is left to good sense to place the boundaries. Landforms change rather slowly through the years and have a strong influence on the other components of landscape ecosystems. It seems logical to make full use of landforms in locating ecologically significant boundaries whenever possible.

A tentative map of the Life Zones of Saskatchewan is presented in Figure 35 and briefly described in Table 1. The boundary lines are somewhat arbitrary for the reasons just given but they serve the purpose of defining large landscape ecosystems that have some distinctive characteristics. The Life Zones provide a useful framework for examination of the smaller landscape types of the province.

Figure 34 - Landscape Component Maps

NATURAL VEGETATION



FORESTS

Sub-arctic Forest Tundra Transition

Northern Coniferous

Mixed Wood

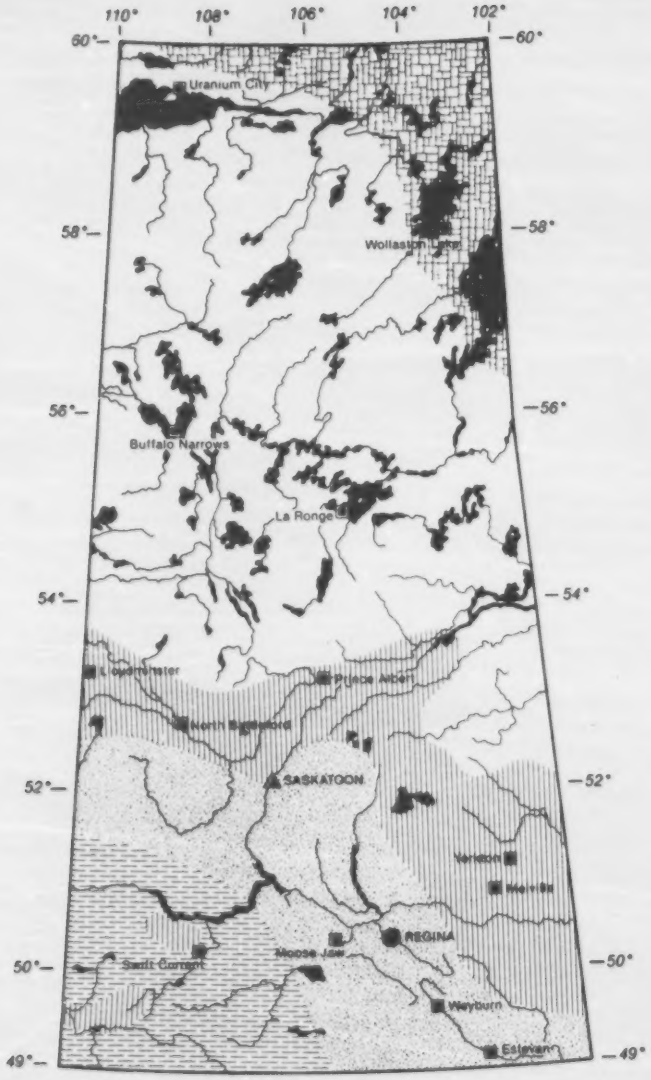
PRAIRIES

Aspen Parkland

Mid-grass Prairie

Short grass or Mixed Prairie

CLIMATIC REGIONS



Arctic Transitional

Sub-arctic

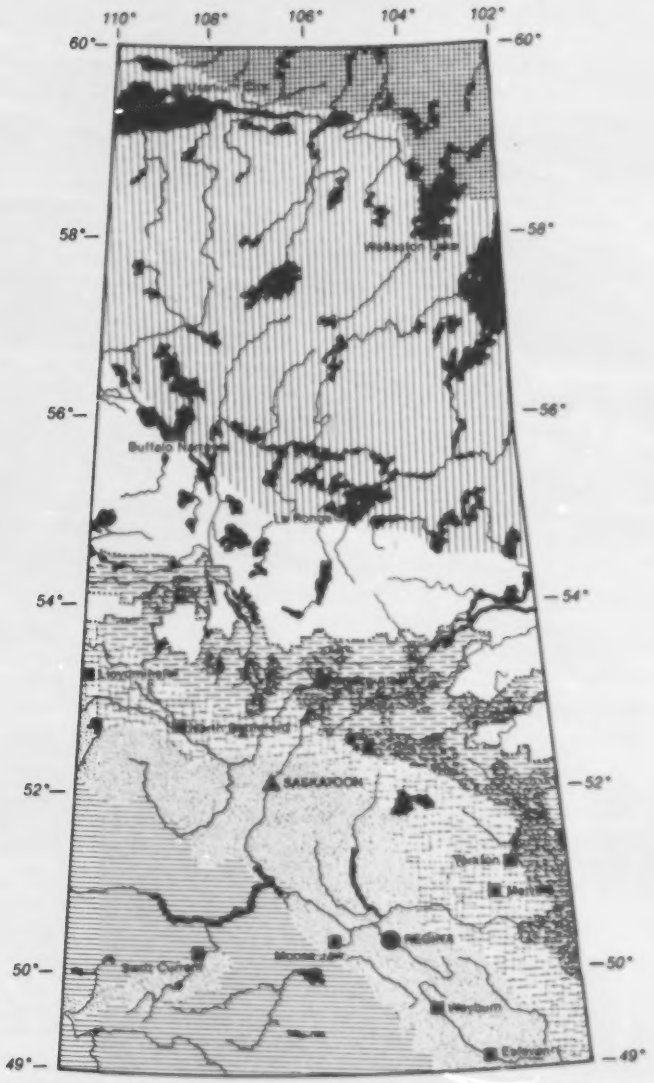
Humid Continental

Sub-humid Continental

Semi-arid

Figure 34B

ZONAL SOILS



- Forest-Tundra, Podzolic and Organic Soils with Rock Outcrops
- Podzolic and Organic Soils with Rock Outcrops
- Podzolic and Organic Soils
- Grey Wooded Podzolic
- Transition (Black-Grey) Organic and Meadow Soils
- Black Soils
- Dark Brown Soils
- Brown Soils

Figure 34C

Figure 35 - Life Zones of Saskatchewan

9. *Open Coniferous (Spruce-Pine Forest) Podzolic & frozen Organic*

8. *Open Coniferous (Pine-Spruce Forest) Podzolic Soil*

7. *Closed Coniferous Forest Podzolic Soil*

6. *Coniferous-Deciduous Forest Grey Wooded & Organic Soils*

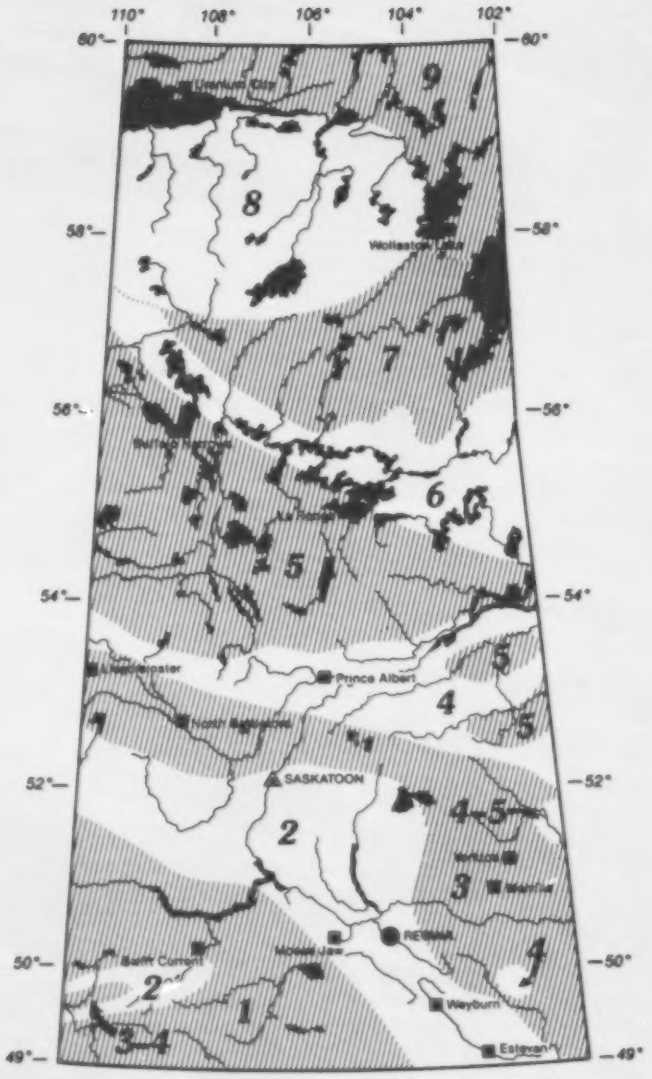
5. *Deciduous-Coniferous Forest Grey Wooded & Organic Soils*

4. *Deciduous Forest (scattered conifers) Dark Grey & Organic Soils*

3. *Parkland (Grass & Deciduous Trees) Black Soil*

2. *Grassland Dark Brown Soil*

1. *Grassland Brown Soil*



3. Local Landscapes and Catenas

Within the large Life Zones or regional landscapes, land units of smaller sizes — ecosystems within ecosystems — can be defined from aerial photographs and studies on the ground. One useful size is the "local landscape", based on individual glacial, proglacial and postglacial landforms. On each, there is a "catena" (interlinked chain) of mini-landscapes corresponding to the topographic sequence of slope positions or facets.

In defining successively smaller landscapes, we rely heavily on the landform, which is the surface shape of the earth plus the underlying geology that gives the form substance. The reasons are most evident when large areas are considered.

Table 1 - Typical Climate, Vegetation, Animal and Soil of Nine Saskatchewan Life Zones

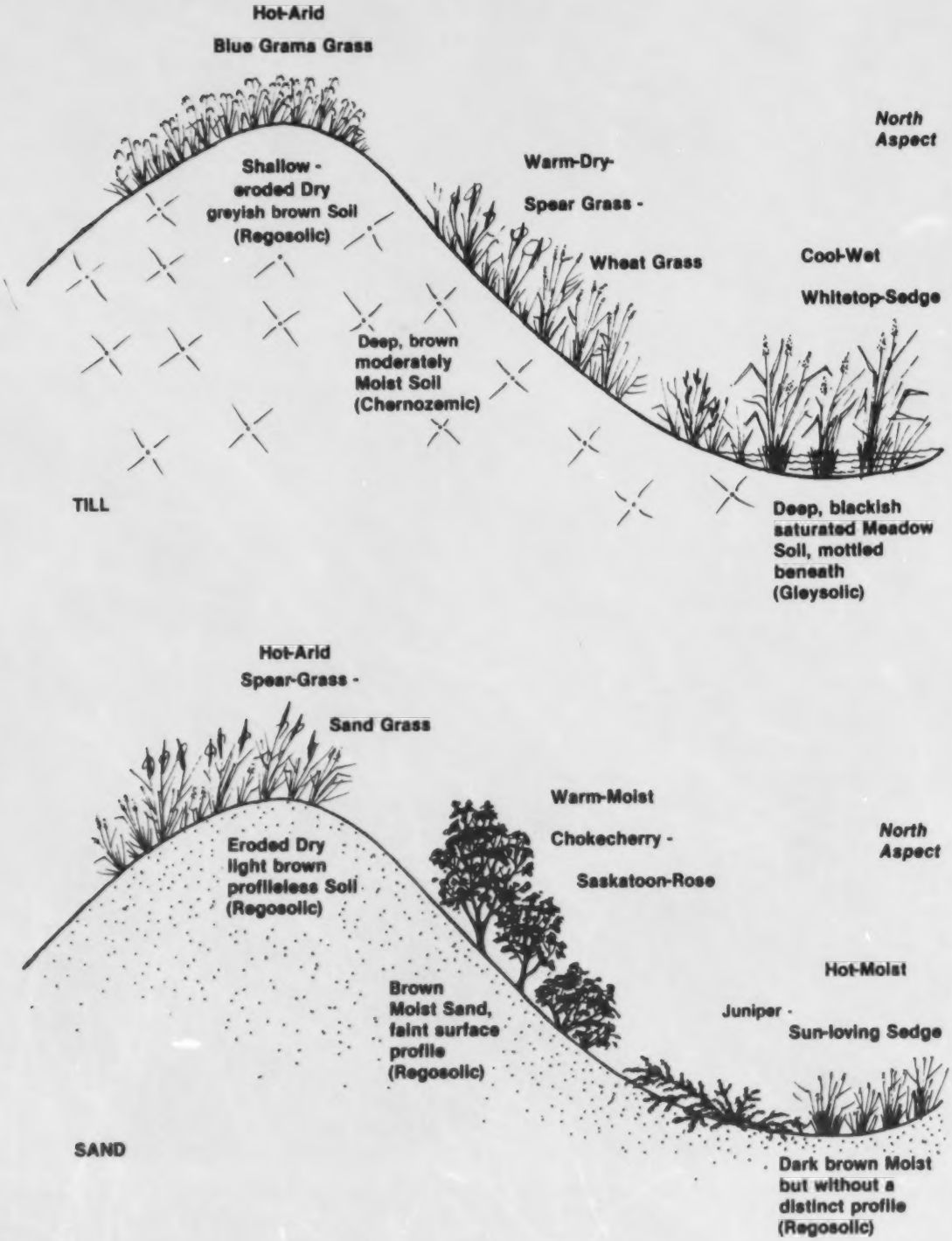
Zone	Climate*	Vegetation	Ungulate	Soil**
9.	Humid & Very Cold	Black Spruce; some Pine Birch & many Lichens (Open Lichen Woodland)	Barren-ground Caribou	Shallow Podzolic, rocky Regosolic & frozen Organic
8.	Transitional	Pine; some Spruce & Birch, Lichens		Podzolic on deep sands
7.	Humid & Cold	Black Spruce, Pine & Larch with Mosses; some Aspen & Birch (Closed Coniferous)	Moose	Shallow Podzolic, rocky Regosolic & Organic
6.	Transitional	Mostly Evergreen but with Deciduous Trees (Mixedwoods)	Organic	Podzolic (Luvisolic) Grey Wooded &
5.	Subhumid & Cool	Mixed Deciduous - Evergreen Trees with Shrubs, Herbs & Mosses	Wapiti (Elk)	Deep Podzolic (Luvisolic) Grey Wooded & Organic
4.	Transitional	Aspen, Poplar; some Spruce & Pine and many Shrubs		Chernozemic Dark Grey & Gleyzolic
3.	Dry & Warm	Mid Grasses, Shrubs, Aspen (Fescue Parkland)	Deer	Chernozemic Black, relatively deep
2.	Transitional	Mixed Prairie, Spear Grass, Wheat Grass		Chernozemic Dark Brown, moderately deep
1.	Very Dry & Warm	Short & Mid Grass Mixed Prairie; Blue Grama, Spear Grass	Pronghorn (Antelope)	Chernozemic Brown, relatively shallow

* *Climatic descriptions based on seasonal water deficits, summer heat units and January mean daily temperatures.*
** *Soil names are explained in the following sections.*

Then, it is clear that a major change in landform, such as that between the Cypress Hills and the adjoining plains, is paralleled by striking changes in the climate-vegetation-animals-soils landscapes. With smaller areas the differences in the visible components of vegetation, soils and land use are sometimes less obvious. Nevertheless, they are readily picked out at the level of local landscapes, based on sandhills, till plains, hummocky moraine and so on. Even when we look at individual knolls, plains and valleys, close examination shows distinctive differences that give a recurring pattern matched to these minor landforms. South-facing slopes, north-facing slopes, upper slopes and lower slopes, all have characteristic features.

Figure 36 - Landscape Catenas

Landscape Catenas ("chains" of climate-vegetation-soil) on two different substrata of similar surface form, in the same Life Zone of southern Saskatchewan.



Relative to man's size, local landscapes are of a magnitude that seems about right for study, understanding, and use. They are readily recognizable and biologically significant. Their properties are important to successful agriculture, forestry, engineering, wildlife management and to most other land use. Local landscapes are a good place to start developing an appreciation of landscape ecology.

Within the same Life Zone, local landscapes reflect the influence of different local landforms. Figure 36 shows a comparison of two local landscapes and their catenas, on a till knoll and on a similarly shaped sandhill, in the southernmost Life Zone 1 in Saskatchewan. The different slope sequences of climate-vegetation-soil develop because of the different way that each landform interacts with sunlight, wind, rain, snow, and evaporation. Comparing north-facing slopes only, water is retained near the surface in the till because of its finer soil texture, establishing conditions that promote the growth of grasses. But water moves to greater depths in sand because of its coarser texture. This favours the survival of shrubs. In each case the appropriate kinds of animals and soil profiles naturally follow, with all parts matched to make up the two distinct local landscapes and their catenary parts.

The idea of the wholeness of landscapes needs to be kept constantly in mind. All the phenomena called "parts" — the surface form, climate, vegetation, resident animals, and soils — have developed together, as sub-systems of the biosphere. To separate them is to look at the anatomy of landscapes. Studying anatomy helps us to understand how the parts function, and how they are related to the whole landscape, but we must not lose sight of the fact that nature is unified, and the parts do not exist, or function, except as part of the overall system. Some anatomical notes concerning the components of local landscapes follow.

4. The Earth Layer of Landscape Ecosystems - Soils

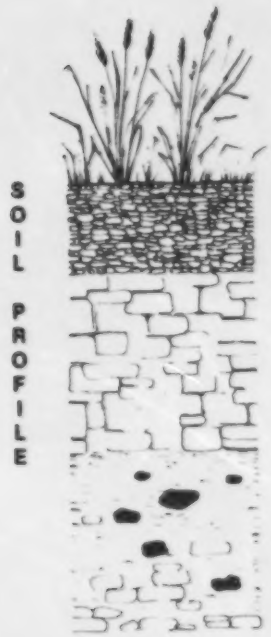
The soil is the basal layer of the ecosystem. It is typically a mixture of water and gases from the atmosphere; organic matter from micro-organisims, plants and animals; and inorganic mineral matter from the landform under it. The force of gravity, precipitation and radiant energy tend to arrange the organic and inorganic constituents in horizontal layers so that soils in profile usually show "horizons" (labelled A, B and C from top to bottom), each with characteristic colour, structure and composition. Figure 37 illustrates a grassland profile as well as the catena of profiles on a slope. In the latter, the horizons change along the gradient from dry knoll to wet hollow. Figure 38 shows how the vegetation changes in parallel.

Soil profiles are good indicators of landscape history over time periods in excess of 100 years. Those skilled in the interpretation of soils can tell much about the environment in which they formed: the nature of the climate (wet or dry), the plant cover (grass or trees), the animals (surface-living or burrowing), and the groundwater (saline or fresh). Such detective work is based on ecological relationships that are visible throughout the province.

(1) Major Kinds of Soils

Soil-forming processes vary, depending on the different interactions of climates, biota, and landforms in different landform situations. From a regional viewpoint, there are two major kinds of soils in the province: those in the dry southern grasslands (Chernozemic) and those of the moister northern forestlands (Podzolic). The surface horizon of the grassland soils is dark and fertile due to the accumulation of humus from generations of grass and herb roots within the soil. By contrast, most of the organic matter of forest soils tends to accumulate *on*, rather than *in* the upper mineral horizon which is frequently leached and grey in colour,

Figure 37 - The Soil Profile - Southern Saskatchewan Life Zones



Major Horizons

A - surface soil, granular, fertile with many micro-organisms & roots

B - subsoil, blocky or forming narrow columns when dry; fortified by materials leached down from the A

C - parent geological material; glacial drift drift or bedrock

Descriptive Modifiers

h - enriched with humus (organic matter) e.g. Ah under prairie.

t - enriched with clay (often leached down from horizon above) e.g. Bt under Ae.

ca - enriched with carbonates (leached from horizons above) e.g. Cca

s - enriched with non-carbonate salts (often from groundwater) e.g. Bs, Cs.

e - eluviated or leached e.g. Ae

g - gleyed or water-logged; e.g. Bg, Cg.

Knoll

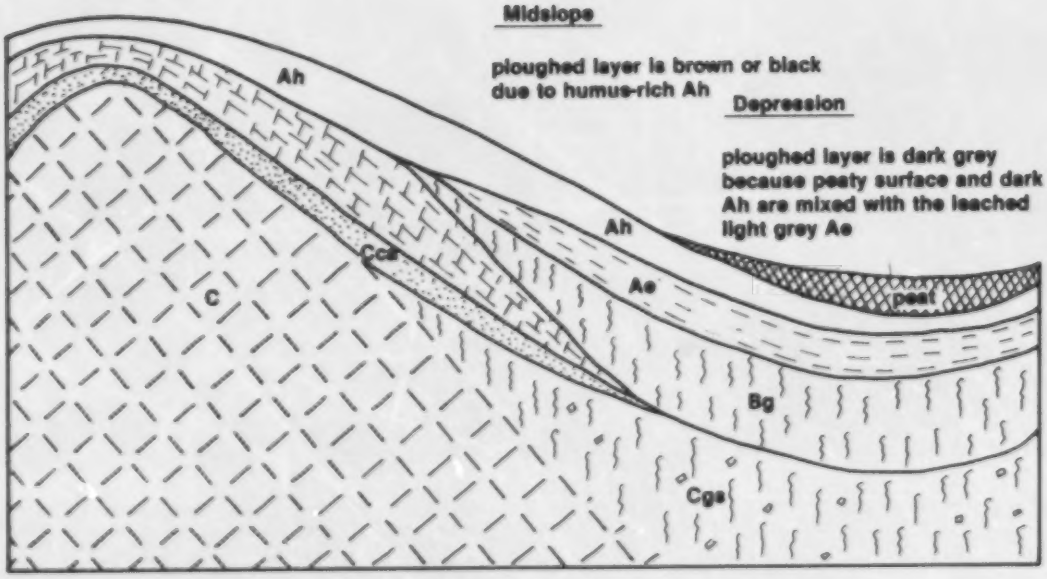
ploughed layer is light grey because Cca is turned up

Midslope

ploughed layer is brown or black due to humus-rich Ah

Depression

ploughed layer is dark grey because peaty surface and dark Ah are mixed with the leached light grey Ae



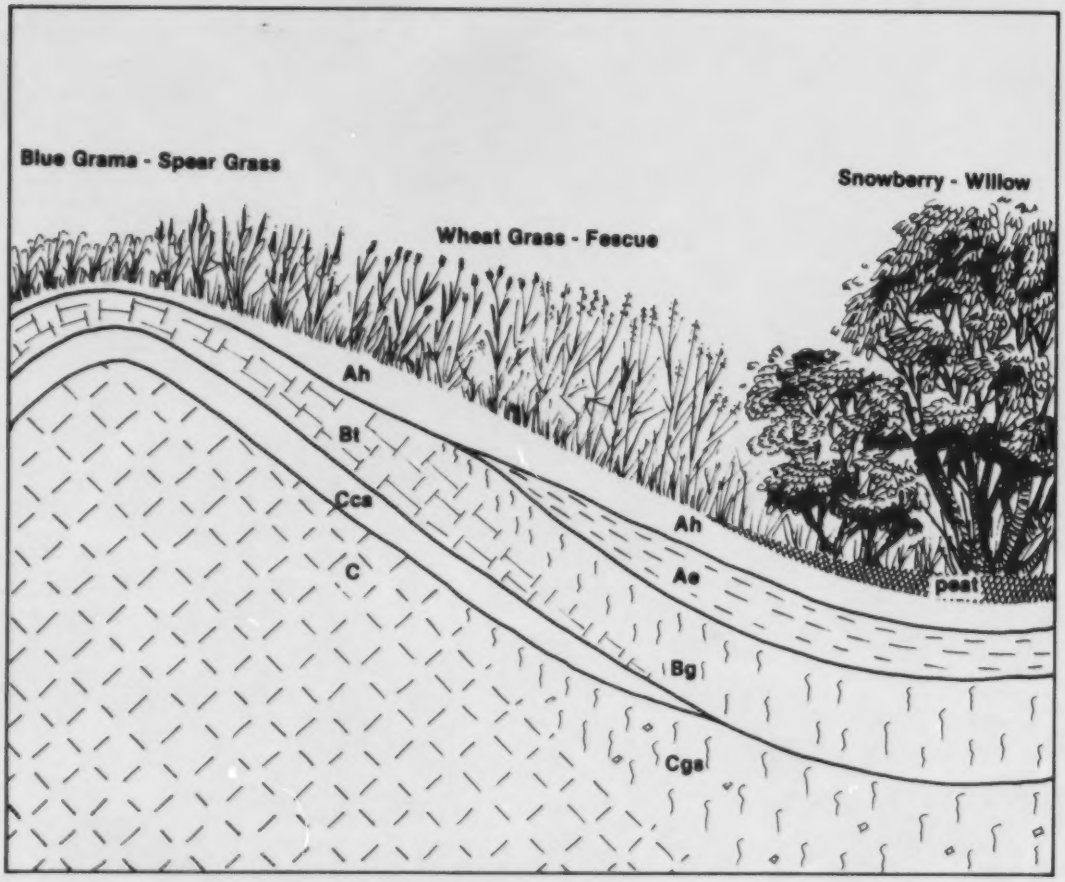
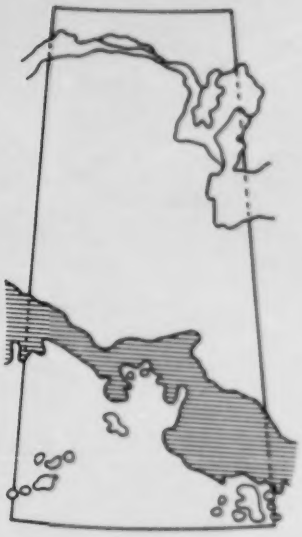


Figure 38 - Related Soil and Vegetation Changes on a Prairie Slope

Other major soils have formed under the overriding influence of particular environments. Saline soils (Solonetzic) are most commonly associated with Chernozemic (Grassland) soils because the droughtiness and high evaporation of the grasslands tends to concentrate salts at the surface. Peat soils (Organic) are especially widespread in the north where there are many glaciated basins and where the cool climate slows the decay of dead water plants. Wet mineral soils (Gleysolic) occur wherever excess moisture and poor aeration dominate the soil-forming process, while weak-profile, poorly developed soils (Regosolic) usually signify surface disturbance or resistant mineral materials that restrict the development of A and B horizons. The general spatial relationships of the six soil "orders" are shown in Figure 39 and Table 2.

Figure 39 - Major Soils of Saskatchewan



Organic Soils (peat), commonest in Forestland

Podzolic* Soils in Forestland

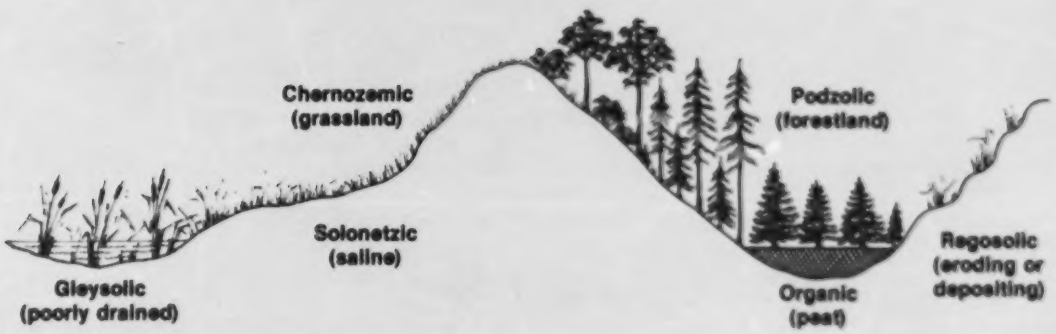
Solonetzic Soils (saline), commonest in Grassland

Regosolic Soils (weakly developed) & Gleysolic Soils (poorly drained) occur throughout.

Transitional Podzolic to Chernozemic

Chernozemic Soils in Grassland

* *The Soil Survey recognizes three related soil "orders" in the north: Podzolic, Luvisolic and Brunisolic. They are grouped here as Podzolic Soils because of certain shared similarities in genesis.*



Soil Orders	Life Zones	Drainage & Surface	Vegetation
Chernozemic (grass root humus in A horizon)	1. Brown Soil 2. Dark Brown 3. Black 4. Dark Grey	Mostly well-drained convex surfaces plus some that are imperfectly drained	Grasses & Hebs Grasses & Herbs Parkland (Tree & Grass)
Podzolic (tree leaf litter on surface)	5. Grey Wooded 6. Grey Wooded 7. Podzolic 8. Podzolic 9. Podzolic	Mostly well-drained uplands plus some imperfectly drained	Mixedwoods Mixedwoods Conifers Conifers Conifers
Solonetzic (saline)	1. Brown Soil 2. Dark Brown	Imperfectly to poorly drained	Salt-loving plants in Salt Meadows & Marshes
Regosolic (weakly developed)	All Zones	Various but mostly well-drained	All kinds
Gleysolic (poorly drained)	All Zones	Poorly drained depressional lowlands	Water-loving plants in Fresh Meadows & Marshes
Organic (peat)	Mostly Zones 4, 5, 6	Poorly drained depressional lowlands	Peat Mosses, Sedges, Evergreen Shrubs

Table 2 - Major Soils of Saskatchewan
Six soil orders in Saskatchewan related to Life Zones, drainage and vegetation.

(2) Soils of Life Zones and Catenas

Within the major soil categories a number of distinct soil classes are recognized by colour and composition. Thus the chernozemic grassland soils and the podzolic forest soils are often subdivided geographically into zonal units. If you travelled from the International Border northward to Prince Albert or North Battleford, looking only at soil profiles on well-drained slopes, you would notice that the colour of the topsoil (A horizon) changes from brown to dark brown to black. Continuing on to the north it becomes dark grey and then light grey.

Life Zone I of Figure 35 is the chernozemic brown soil zone where the original vegetation was relatively sparse spear grass-blue grama cover. Life Zone 2 is the dark brown soil zone, which had a denser cover of spear grass-wheat grass. Life Zone 3 is the black soil that used to be covered with thick fescue grass. Along a transect from south to north the climate becomes moister, the vegetation increases in density and the humus content of the A horizon darkens and deepens. At the point where trees come to dominate, the podzolization process replaces chernozemic profiles with a variety of grey and brown profiles that characterize the northern Life Zones.

Just as soils vary with latitude, so they change with altitude. Black and dark grey soils are found on top of the Cypress Hills while at lower altitudes on the surrounding plains the soils are dark brown and brown. Dark grey soils occur under Aspen forest on the Moose Mountain, contrasting with the black soils of the adjacent agricultural lowlands. These features are indicated on the Life Zone map, Figure 35. An interesting corollary is that in different Life Zones, different landscapes (soils + biota + climate) are developed on landforms of similar shape and composition.

Within any one Life Zone, each different local landscape has a characteristic catena of soil profiles that is related to the topography. Changes in the catena indicate underlying landform variations, such as surface stability, moisture supply, salinity and drainage. It is possible for a single catena to include profiles that are regosolic (on eroding knolls), chernozemic (deep moist soils on gentle side slopes), solonetzic (hard, poorly structured soils on saline lower slopes) and gleysolic (dull-coloured, mottled wet soils in poorly drained depressions).

The members, or "links", of every catena correspond to slope facets whose positions (upper or lower), aspects (facing into or away from the sun) and configurations (concave or convex) control amounts of energy and moisture received. In areas of high relief where slopes are long, the differences between upper and lower positions or between north and south aspects may be almost as great as the differences visible on similar landforms in adjacent Life Zones. Despite the fact that they occur close together, the most contrasting members of the catena apparently occupy environments as different as those of regional landscapes lying tens or hundreds of miles apart. South-facing dry upper slopes often show soil profiles and plant cover typical of mid slopes in the Life Zone to the south, while just over the hill on the north-facing moist lower slopes the profiles and vegetations closely resemble those of mid slopes in the Life Zone to the north. Because of this, hilly terrain is varied and interesting. It is much more a mosaic of different environments, mini-landscapes and habitats than comparable areas of flatland.

(3) Soil Maps and Mapping Units

Soil maps and bulletins produced by the Soil Survey in Saskatchewan cover all the south of the province and provide a mine of valuable information on the "earth layer" of landscapes. The map unit used for a general description is the "Soil Association". This corresponds to what we have been referring to as the "local landscape". It is the pattern of soils developed on a recognizable kind of landform within a particular Life Zone.

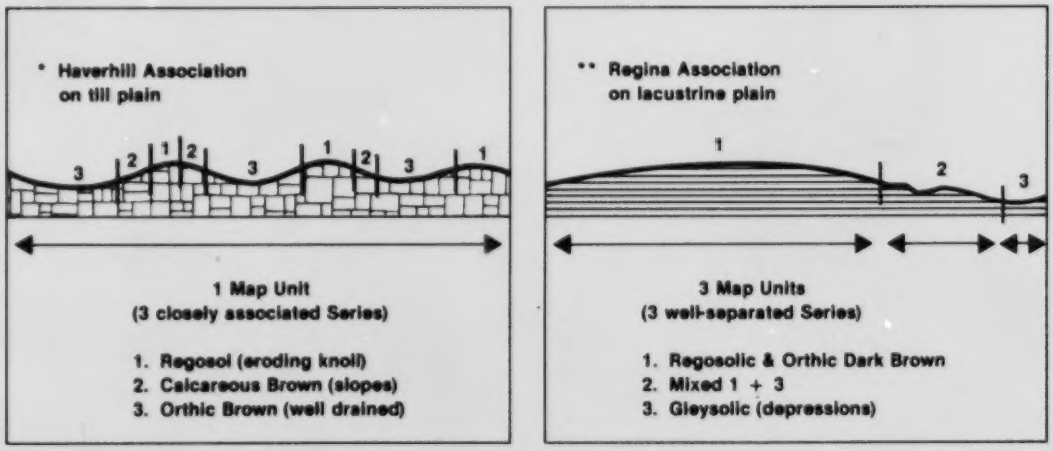
For more detailed land uses, the Soil Association is subdivided into map units consisting of single or associated catenary members, each called a "Soil Series" differentiated by profile characteristics that reflect such important ecological variations as relative topographic variation, moistness and texture. Thus the Regina Association consists of all the lacustrine clay soils (formed on the bottom sediments of old proglacial Lake Regina) in the dark brown soil zone (Life Zone 2). It is mapped as three sub-units of which the first is dominated by well-drained regosolic members and the third is dominated by poorly drained gleysolic members. The second is intermediate.

Several examples of common Soil Associations, Series and Map Units are shown in Table 3.

Table 3 - Soil Associations on Three Landforms in Southern Life Zones

Zone	Moraine of medium-textured calcareous till	Outwash of coarse sand and gravel	Lacustrine Plain of calcareous clay
Brown Soil Chernozemic (Life Zone 1)	Haverhill*	Chaplin	Sceptre
Dark Brown Soil Chernozemic (Life Zone 2)	Weyburn	Bigger	Regina
Black Soil Chernozemic (Life Zone 3)	Oxbow	Whitesand	Melfort (silty)
Dark Grey Soil Transitional (Life Zone 4)	Whitewood	Glenbush	Tisdale
Grey Wooded Soil Podzolic (Life Zone 5)	Waitville	Bodmin	Eldersley

Note: Soil Associations are named after towns near where they were first described.



5. The Air Layer of Landscape Ecosystems - Climate

The term "climate" describes the averaged characteristics of the atmospheric part of the biosphere. When applied to landscape ecosystems of decreasing size, the terms "topoclimate" and "microclimate" are more appropriately used.

Like the soil and water layers on which it rests, the air-climate layer has a profile that varies in composition, structure and energy from the ground surface upwards. Unlike soils, the air profile cannot be seen, so we must rely on instruments to detect the layers of different temperature, humidity, carbon dioxide concentration, and so on. It is useful to think of plants as having their tops "rooted" in the layered air, just as their bottoms are rooted in the layered soil.

Studies have been made to show that air-climate profiles are related to the other parts of the landscapes with which they are associated. In other words, a particular landscape ecosystem possesses a particular climate. This is because what we call "climate", which includes the range of radiation, temperature, precipitation, and evapotranspiration, depends in large part on the elevation, slope and texture of landforms, and the soil-vegetation combinations that occupy their surfaces. As with soils, catenas of local climates form topographic patterns on local landforms. Recognition of the close relationship of climate and landscapes has led to the study of "topoclimatology" or "terrain climatology". It is aimed at understanding the climate near the ground where animals and plants live and thrive or suffer and die. The following are some generalizations concerning topographic effects on climate.

(1) Relationships with Altitude

The atmosphere is held to the earth by the force of gravity. Its weight produces pressure, which may be measured with a barometer. Low areas have a greater weight of air above them than high areas, so air pressure decreases as altitude increases. When a volume of air rises, it expands because of the decrease in pressure. This expansion causes the temperature to drop. The reverse, of course, happens if the air descends and is compressed, as happens when chinook winds come down into southern Alberta and Saskatchewan from the mountains to the west.

The usual decrease in temperature is about 0.5°C with each 100 metre increase in altitude. Thus the average maximum temperature for June at Cypress Hills Park (elevation 1400 metres) is 19°C while at Val Marie (elevation 790 metres) it is 22°C. The cooling effect of rising air results also in increased cloud and precipitation at the higher elevations. Therefore the Cypress Hills and Moose Mountain receive about 100 millimetres more precipitation at their tops than near their bases.

The slopes of high hills that face in the direction from which summer storms advance generally receive more precipitation than lee slopes. Even small hills, by forcing the air to rise as it flows over them, may increase the precipitation significantly, although in many cases the additional rain may carry over and fall on the lee side.

At night, the earth's surface cools by radiating energy to the sky. This is particularly true if there is no cloud cover. The loss of energy causes the air in contact with the earth to cool. Under calm conditions when there is little mixing in of the warmer air above, the surface air may cool sufficiently to cause the formation of dew or even frost. Cold air flows like syrup, sliding off slopes and collecting in low areas, creating evening breezes. Hollows that may be warmer than slopes during the day, because of shelter from the mixing effects of the wind, can become cold frost-pockets at night. The daily range of temperatures is therefore greatest on concave topography (hollows and valleys) and least on convex topography (knolls and ridges). Measurements in the sandhills near Dundurn have shown that the day-night range of midsummer temperatures at ground surface is from 46° to 0°C in blowout depressions as compared to a range of 41°C to 5°C on nearby knolls. The length of the frost-free season may be much shortened on lowlands that receive and trap cold air from surrounding slopes.

(2) Relationships with Aspect (slope direction)

Under cloudy conditions the sun's radiation is diffused and all slopes receive much the same energy. But in sunny Saskatchewan both the slope angle and direction that each landscape area faces greatly affect the amount of solar radiation it receives. On summer mornings the sun shines on east-facing slopes that are still cool and dewy from the preceding night. It takes a while to dry and heat them. But as the sun swings toward the south and west, it delivers radiation to

slopes already dried and warmed by daytime breezes. So west-facing slopes tend to reach higher temperatures than their east-facing counterparts. Evapotranspiration varies along with the temperature, making the warmer south and west slopes drier than the cooler east and north slopes. Vegetation and soil indicate the differences nicely, and it is common to find grasses and grassland soils (chernozemic) on the sunny slopes, woody plants and forest-like soils (podzolic) on the opposite shady slopes.

Slope direction is also important to the winter accumulation of snow. Exposed windward slopes are blown free of snow while sheltered lee slopes collect snow banks that keep the soil temperatures relatively warm. Snow banks also contribute to soil moisture in the spring and early summer. Vegetation helps to trap snow, particularly where it grows tall on east and north aspects and in moist gullies and around kettle depressions. Clearing the trees and shrubs from such locations can drastically change the local moisture conditions and may even affect the below-ground water table.

(3) Relationships with Water Retention

The solar radiation absorbed by landscapes either heats the materials it strikes, causing a rise in temperature, or it is dissipated by the evaporation of water. Where it causes warming, the heat flows from the warm surface partly into the soil and partly into the atmosphere. Where it causes evaporation, the energy is used to change water from the liquid to the vapour state without a change in temperature. Therefore densely vegetated areas with adequate soil moisture use most of their absorbed energy in evapotranspiration and stay cool. On the other hand, dry areas lack the "air conditioning" effect of evapotranspiration and can only dissipate their energy by warming up.

Water also stores large quantities of energy without great changes in its temperature, which is the reason that lakes heat more slowly than air and earth. At night when dry landscapes are cooling rapidly by radiation to the sky, wet landscapes stay fairly warm as the heat stored during the day is released more slowly. Thus the presence of water contributes to the moderation of temperatures during both the day and the night.

Whether or not landscapes retain moisture at or near the surface has a great influence on their temperature regimes. Coarse-material landforms such as sand dunes and outwash plains are well-drained and surface-dry. They tend to warm quickly in the sun and to cool as quickly at night. Frost pockets are common in shallow dry depressions on such landforms. In contrast, fine-material landforms such as till plains and lacustrine basins are water-retentive, warming and cooling to more moderate temperatures day and night. Summer frosts are almost unknown in kettle depressions on such landforms because their shallow sloughs store heat in daytime and release it slowly at night.

(4) Latitude, Altitude and Phenology

In the middle latitudes of the northern hemisphere where Saskatchewan lies, the average or mean temperature decreases about 0.75°C for each degree of latitude toward the north pole. As has just been mentioned, there is also a usual altitudinal effect on temperature; a decrease of about 0.5°C with each rise of 100 metres. This parallel between the effects of latitude and the effects of altitude helps to explain the presence of northern types of landscapes on high plateaus in the south and of southern types of landscapes on lowlands or sunny slopes in the north. How can the environments be similar in such widely separated places? An examination of two important related parts of climate throws some light on the question. These are, energy and moisture.

The energy available for various processes at the earth's surface is net radiation, the difference between what comes in from the sun and sky and what is lost by reflection and re-radiation by the earth. It is roughly indicated by air temperature, especially in dry climates where only a small proportion goes into evapotranspiration. Because temperature is easily measured, various methods have been proposed for recording meaningful regional temperature characteristics. The number of **frost-free days** between the last spring frost and the first fall frost can be counted and averaged over the years. Another index, **growing degree days**, can be calculated by adding up the daily temperatures in excess of 5°C throughout the growing season and averaging for a number of years. When such temperature indexes are plotted on maps of the province they show a general decrease from south to north as would be expected with a lowering sun angle in the north. But the gradient of decrease is not regular because the landscape modifies climate by affecting the net radiation, especially the outgoing reflection and re-radiation components. Because of their exposure, hills lose more energy by re-radiation than sheltered valleys and low-lying areas.

Next consider the moisture available for ecosystem processes at the earth's surface. Net moisture is the difference between what comes to the surface from the atmosphere and what is evaporated and transpired back. This concept is not very useful because in Saskatchewan's dry climate it averages zero over the year. In fact, more moisture could be lost through evapotranspiration than usually comes in as rain and snowfall. In some parts of the province where water is available, the potential loss is made up in the summer by irrigation. The difference between precipitation and potential evapotranspiration (which is the total that could be evaporated if water were freely available) is called the "water deficit". This is a useful moisture-drought index. In the southern part of the province the water deficit during the growing season from May to September is as much as 460mm. Northward the water deficit is less because evaporation in the summer is less. But again the decrease is not regular because the terrain modifies climate, especially affecting the incoming precipitation. Hills and high areas attract more rainfall and snow than valleys and low areas.

The two climatic variables — net radiation and water deficit — are not independent. Net radiation provides the energy for evapotranspiration. Winds also affect both, transferring energy and hastening or slowing evaporation. Dry surfaces generally reflect and re-radiate more energy than moister surfaces, resulting in a reduction in net radiation. All the climatic components interact with soil, vegetation and other land features that, by reflecting or absorbing energy and by evaporating or absorbing moisture, contribute to particular landscape climates. Therefore it is not only climates that vary latitudinally and altitudinally, but whole landscape ecosystems with their climate-soil-vegetation-animal parts.

Interesting comparisons can be made between latitudinal and altitudinal changes in landscapes. In the southwest the Cypress Hills rise above the "dry grassland - ground squirrel - brown soil" landscape of Life Zone 1. Near the top of the hills, some 460 metres above the plains, the climate is sufficiently altered by altitude to support a "pine forest - tree squirrel - dark grey soil" landscape, which resembles terrain near Prince Albert, several hundred kilometres to the north in Life Zone 4. Similarly, a climb to the top of Last Mountain reveals aspen forest similar to that northward at lower elevations near Kamsack. The fescue grass - black soil landscape on some parts of the Allan Hills between Saskatoon and Regina resembles the lower-lying terrain bordering the North Saskatchewan River near Battleford.

The growth and behaviour of many organisms are keyed to the seasonal changes of climate as it varies with landscapes. The times of leafing and flowering of plants, and time of the return and nesting of birds, are generally earlier in the south than in the north, and earlier at low altitudes than in highlands. Study of the

seasonal timing periodicities of growth and behaviour as influenced by weather and climate is called "Phenology".

Table 4 is an example of a phenological record, showing the relative times of arrival of migrant birds in the spring at Regina. The earliest and latest arrivals are not shown because they are completely off the chart. The horned lark arrives in mid-February and the black-billed cuckoo in mid-June — a phenological difference of four months! Notice that the ducks that feed in shallow water, the dabblers, mostly arrive before the diving ducks. The birds dependent on insects for their fuel (swallows, flycatchers and warblers) tend to come late. Table 5 relates a few early flowering prairie plants to times of return of some of the birds.

About 60 years ago Hopkins* suggested a simple relationship between the latitudinal and altitudinal effects on phenology. His rule-of-thumb was that each degree of latitude (approximately 115 km) is equivalent to 122 metres altitude and makes a difference of four days in phenology. Applied to some Saskatchewan places it suggests that the aspen forests on Moose Mountain at latitude 50° and altitude 730 metres ought to leaf out in the spring at about the same time as the aspen forests near the town of Hudson Bay at latitude 53° and altitude 365 metres. By the same rule, crocuses ought to flower about two weeks earlier in the spring at Maple Creek (altitude 820 metres) than just to the south on the Cypress Hills plateau (altitude 1200 metres). The idea is interesting but inexact, for there are many landscape variables that throw it off. Longitude makes a difference and one would expect the warmer southwest of the province to be somewhat "earlier" than the cooler southeast, at the same latitudes and altitudes.

In Montana the records of the flowering times of lilacs were collected with the assistance of country schools in the state. By connecting with lines the places of similar phenology, a map was produced to show regions where blooming was early, intermediate and late. Such maps and phenological calendars, giving average dates for selected biological events, are useful supplements to conventional climatic information.

* Hopkins, A. D. (1918). *Periodical events and natural laws as guides to agricultural research and practice.* U.S. Weather Bulletin #643.

Table 4 - Usual Time of Return of Common Birds to Regina
(from M. Belcher's "Birds of Regina")

	March 15-21	22-31	April 1-7	8-14	15-21	22-30	May 1-7	8-14	15-21	22-30
Ducks		Mallard Pintail Wigeon Shoveler Common Merganser	G-w Teal Redhead Canvasback L Scaup R-breasted Merganser	Gadwall Bufflehead	Blue-winged Teal	Ruddy Duck				
Other Waterfowl Gulls (Gu) Grebes (Gr)		Canada Goose	Ring-billed Gu	Pelican Coot Whistling Swan	Snow Goose Franklin Gu Pied-bill Gr	Cormorant Horned Gr	Common Tern Eared Gr Western Gr	Black Tern		
Hawks (H) Owls (O)	Marsh H	Merlin Red-tailed H Rough-legged H	Kestrel Short-eared O	Sharp-shinned H	Swainson's H Burrowing O		Broad-winged H			
Shore & Marsh. Sand-pipers (S)				Yellowlegs Baird's S Sandhill Crane	C Snipe	Least S Willet Avocet Marbled Godwit	Spotted S Solitary S Bittern Wilson's Phalarope	Upland S Stilt S Northern Phalarope		
Black-birds (B) Larks	Starling	Red-winged B Meadowlark		Brewer's B Grackle		Yellow-headed B	Brown-headed Cowbird		N Oriole	Bobolink
Sparrows (Sp) Finches	Tree Sp	Junco Lapland Longspur		Fox Sp Song Sp	Vesper Sp Chestnut-collared Longspur	White-crowned Sp Savanna Sp	Chipping Sp Clay-colored Sp White-throated Sp Towee		Lark Bunting Goldfinch Rose-breasted Grosbeak	
Thrushes (T) Swallow (Sw) Flycatchers(F)		Robin Mountain Bluebird			Hermit T Phoebes		Gray-cheeked T Swainson's T Barn Sw	Veery Least F Olive-sided F Kingbirds Pewee		
Warblers					Yellow-rump (Myrtle)	Orange-crowned	Palm Black-poll Tennessee Black & White	Yellow Yellow-throat Ovenbird	Mourning Wilson's Redstart	Magnolia
Miscel-laneous	Crow		Shrike	Flicker Kingfisher Mourning Dove	Yellow-b Sapsucker Brown Creeper	Sprague's Pipit	Red-breasted Nuthatch	Brown Thrasher	House Wren Catbird	Cedar Waxwing

Table 5 - Coincidences of Phenological Events in Southern Saskatchewan
Average times of plants' first flowering and of birds' return.

	Date	Plants Bloom*	Birds Return**
April	3rd Week	Crocus	Franklin Gull Myrtle Warbler
	4th Week	Moss Phlox Dandelion	Yellow-headed Blackbird White-crowned Sparrow
May	1st Week	Prairie Buttercup Early Cinquefoil	Brown-headed Cowbird Chipping Sparrow
	2nd Week	Golden Bean Three-flowered Avens	Kingbirds (Eastern & Western) Brown Thrasher
	3rd Week	Saskatoon Prairie Onion	Goldfinch Catbird
	4th Week	Shooting Star Wild Onion	Cedar Waxwing Magnolia Warbler

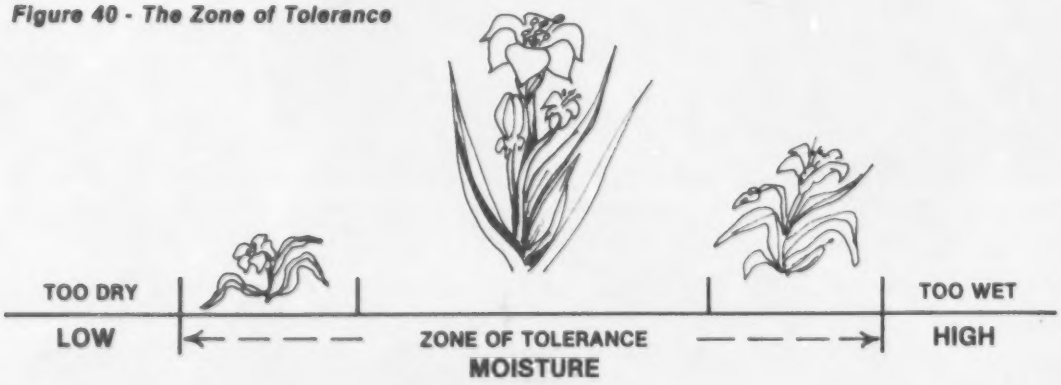
* From Budd, A. C. & J. B. Campbell, 1959. Flowering sequence of a local flora. *Journal of Range Management* 12: 127:132.
** From Belcher, M. 1966. *Birds of Regina.* Special Publication, Saskatchewan Natural History Society.

6. Plant Cover and Animals on Uplands

(1) Introduction

Every organism is adapted to a certain range of landscapes. For each component of the landscape (temperature, moisture, salinity, etc.) each species has an "optimum range" within which it thrives, and a somewhat broader "range of tolerance" outside of which it will perish. Between the two, on either side of the optimum range, the species will survive, but not necessarily thrive and reproduce (Figure 40). It follows then that a species will occur only when every environmental component falls within the species' range of tolerance. It will do best where many, or most of the components, are within the optimum range, and it will be absent where any one environmental condition is so extreme that it is beyond the species' range of tolerance.

Figure 40 - The Zone of Tolerance



Every kind of plant or animal shows preferences for dry sites or moist, sandy soils or saline, grassland or forest. In its appropriate habitat, each successfully competes with other organisms and keeps its "place in the sun". Once established it contributes to its ecosystems in various ways, modifying the immediate climate, affecting the soil, providing nutrients to its associates. Each organism is at the same time a beneficiary and a maker of its surrounding landscape.

Plants fix solar energy and provide a source of second-hand chemical energy for animals. The metabolic products of both are used and broken down at the ends of food chains by micro-organisms, releasing mineral nutrients for another cycle of organic production. The many kinds of plants, animals and micro-organisms have evolved varied ways of using the resources — nutrients, moisture, energy — of particular landscapes. Phenological differences prevent species from making similar demands on their shared environment at the same time. For example, the plants have "learned" to flower at different times so that competition for insect pollinators is diminished. Again, some of the common prairie species such as June grass are adapted to early growth in the cool spring, putting out new leaves when the soil temperature at 15 cm depth averages about 5°C, while warm-season plants like blue grama begin growth nearly a month later when the soil temperature averages about 11°C. Therefore, aggregations of species are able to live together, without drastic interference and in mutually-supporting ways, forming communities that sustain themselves through complex recycling mechanisms.

It might seem logical to suppose that a homogeneous landform such as a level sand plain would be colonized by only a few species and that a simple community would characterize it. In fact, however, communities are almost always complex, except on sites where the environment is very extreme, as on saline soils. Simple communities such as fields of wheat can only be maintained artificially by periodic tillage and use of herbicides that prevent the natural trend toward diversity. Apparently there are survival values in the cooperative complexity of communities.

Plant-and-animal associations (biotic communities) rarely have exactly the same composition from place to place. Despite the similarity of adjacent localities there are always some species that are present in one and absent from another. These reflect historical differences in migration opportunities or slight variations in soils and local climate. Therefore biotic community types cannot be defined exactly, although they can be described well enough for recognition in terms of structure and general composition.

As with soils and climates, certain characteristics are appropriate for identifying communities on different geographic scales. Large regional plant communities are typified by structure as already shown in Table 2. In that example, the prevailing upland vegetation of Life Zones 1, 3, 5, 7 and 9 is Mixed Prairie, Parkland, Mixedwood Forest, Closed Coniferous Forest and Open Lichen Woodland, respectively. Within Life Zones, at smaller landscape sizes, communities are described with more attention to species composition.

(2) Local and Catenary Communities in Life Zones

Within each Life Zone every kind of local landform supports its distinctive plant community (plus soil, local climate, and animals). The plants that dominate the general landscapes, based on several common landforms, are compared for Life Zones 1, 5 and 9 in Table 6. Note the changes within each Life Zone (the columns) in going from a relatively dry landform (outwash) to a moister one (moraine) and then to a relatively wet landform (lacustrine plain). Reading the table horizontally shows the changes that are primarily due to climate, for the substratum of each row is constant.

Community descriptions such as the above are very broad and give little more than a vague picture of the kind of vegetation present. They are equivalent to characterizing the soils on moraine in Life Zones 1, 5, and 9 as chernozemic, luvisolic and podzolic. A closer view shows that every landscape on its landform base consists of an interlinked mosaic or catena or communities. This was previously shown with reference to topoclimates and to soils. This terrain-oriented classification, identifying the catenas of vegetation and soils fitted to landform facets, is illustrated in Figure 41. On the same kind of surface material (a hill composed of glacial till) within a given Life Zone, there are parallel changes in vegetation-soil across the topographic gradient, reflecting the climate-landform interactions.

Lanform	Life Zone 1	Life Zone 5	Life Zone 9
Sand & Gravel Outwash Plain	Blue Grama - Spear Grass	Jackpine - Aspen	Black Spruce - White Spruce
Loam & Clay Loam Till Plain	Spear Grass - Blue Grama	Aspen - White Spruce	Black Spruce - White Birch
Silty Clay & Clay Lacustrine Plain	Wheat Grass - June Grass	Black Spruce - Larch	Sphagnum Moss - Black Spruce

Table 6 - Community Dominants

The community dominants on three common landforms in three contrasting Life Zones in Saskatchewan. At this particular scale, descriptions are very generalized and cannot recognize catenary variations.

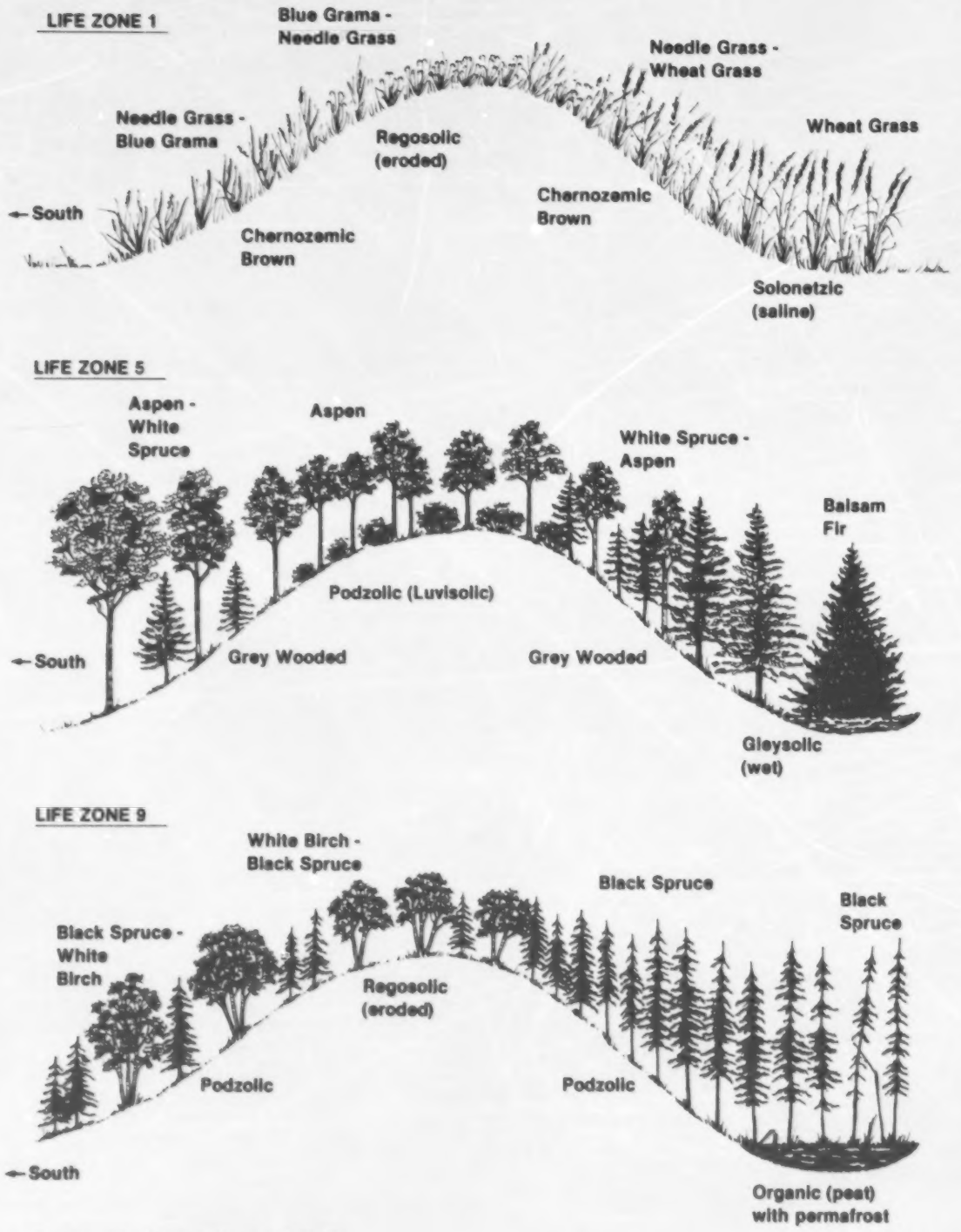


Figure 41 - Vegetation and Soils

Vegetation and soils on one kind of landform (a till knoll) in three Saskatchewan Life Zones (1 - southern, 5 - central, 9 - northern). The different landscape catenas reflect different landform-climate relationships.

By looking at the anatomy of landscapes, as has been done in the preceding sections, the same sorts of relationships for soil, topoclimate and vegetation along the topographic gradients of landforms are revealed. All obviously "go together" as the components of geographic ecosystems, forming catenas of integrated landform-climate-vegetation-soil. In other words, every surrounding landscape is realistically understood as a system of adjusting parts. It is the stage where animals play out their roles and where that greatest actor, man, is busy changing the scenery.

(3) Animals

Because animals are dependent on plants, they "go with" certain vegetation communities. In turn the plants have become dependent on animals for pollination of flowers, dispersal of seeds, loosening of the soil, breakdown of organic matter and return of nutrients to the roots, and for many other symbiotic relationships.

How animals are associated with plants in biotic communities depends partly on size and mobility. Mobile animals like caribou and wolves may range over one or more Life Zones, moving with the season to find their food and shelter. Indeed some birds even shift from continent to continent, using a large part of the biosphere as their habitat. Small, less mobile animals, such as mice, may spend their lives in one local landscape or even in one part of a catena such as the moist lower slopes surrounding a kettle slough. The even smaller flightless insects and micro-organisms are confined to micro-environments, perhaps to one suitable host plant, a log or a root. But whether a large or small area is considered, the greater the variety of landscapes the greater the diversity and richness of the animal life.

The pronghorn and deer of southern Saskatchewan provide interesting examples of animal habitat requirements. Like humans they are attracted to variety in food and shelter. They favour terrain that is a mixture of plains and ravines, grassland and bush. Because of man's interest in hunting, they also require sizeable areas of "escape" terrain if they are to survive. These needs are met in landscapes dissected by coulees or in hilly moraine, places that are sparsely settled because they are too rough, dry or wet to be farmed economically.

Good agricultural land is no longer good habitat for deer and pronghorns. Before breaking by the plough, the rich native prairies were undoubtedly excellent grazing and browsing land for bison and deer, wapiti and pronghorn. Today the undulating glacial lake basins and till plains of the grain belt have a low potential for pronghorn and deer. Their diversity has been reduced in the interests of growing the few cereal grasses that man can eat. Whatever land is prime "human habitat" cannot be trespassed on by major competitors. The only consumers that have managed to survive in the croplands are the small ones such as grasshoppers and mice, and there is a continual war to eliminate them as well.

The appropriation by man of all the most fertile and accessible soils makes it essential that remaining natural landscapes be conserved and protected if other creatures are to be spared. Particularly important are areas that have local climates and food supplies that can carry the ungulates through the winter. The grass-shrub slopes of large valleys are prime habitat because the diverse topography provides protected sunny spots where the animals can forage when the snow is deep elsewhere. For the same reason, sandhill terrain is also excellent winter habitat.

The only way to preserve wildlife, except in zoos, is to preserve habitat. But river valley "breaks" and sandhills can also be made to produce beef and mutton, so more and more of the wildlands are dwindling in the south of the province — disappearing into grazing leases and community pastures.

7. Plant Cover and Animals on Wetlands

(1) Northern Wetlands

Water covers about 30,000 square miles (12%) of the province, according to the *Atlas of Saskatchewan*. Most is in the north where, on some parts of the Precambrian Shield, there is as much water surface as dry land. Within the forested zones, gently shelving lake shores and wet basins have a ground cover of peat, built up by the accumulation of mosses and sedges. There are two main types: **fens** of slightly acid, well-decomposed peat formed from brown mosses and characterized by a surface growth of sedges, willows and larch, and **bogs** of strongly acid raw peat formed from *Sphagnum* moss with a surface growth of evergreen dwarf shrubs and usually some scattered small black spruce.

Fens are much wetter than bogs and, from the air, their surfaces typically appear as a succession of pools or water-filled furrows separated by raised peat ridges, giving the name "patterned fen". There is evidence that bogs develop on top of fens as peat accumulation raises the surface above the water table, thus providing a suitable substratum for the invasion of Sphagnum, Labrador tea and black spruce. Bogs are not particularly good animal habitat but fen margins by streams and lakes are favoured by muskrat and beaver, snowshoe hare and moose as well as other animals.

(2) Southern Wetlands

In the south of the province there are occasional large lakes and millions of small lakes and sloughs. Some are permanent and others dry up between spring and fall. They dot the landscape in both the parkland and the grassland zones, contributing to the underground water table and providing diverse habitat for a great variety of plants and animals. In most cases the large lakes lie in old proglacial basins with here and there a raised beach ridge or terrace, showing where the water level stood at some time in the past. Others lie in spillways and meltwater channels. Most numerous however are the small sloughs that occupy the kettle depressions in till plains and hummocky moraine.

The marshy shores of southern lakes show a rough banding or zonation of vegetation, reflecting the seasonally changing depth of water along the margin. Farthest from shore, in the deep water, there are usually submerged and floating-leaf plants such as water milfoil, water crowfoot and duckweed. Next, toward the margin, lies a dark green zone of bulrushes and cattails, the so-called deep marsh emergents whose firm rooting and stem strength fit them to withstand the force of the waves. Close to the shore is a shallow marsh zone of smaller, lighter green grassy and broad-leaved plants, particularly white-top grass, awned sedge and smartweed. Finally, at the margin, there is a low meadow where reed-grass, asters and dock are often conspicuous. Usually the outermost zones have willows dotted through them, efficient snow collectors that help to renew the water levels each winter and spring. Some of the relationships between the zones and the lakeshore environment are summarized in Figure 42 and Table 7.

Zone	Permanency and Depth of Water	Vegetation	Substratum
1. Aquatic	Flooded throughout the year; depth of water exceeds 20 cm in the fall	Water Milfoil Water Crowfoot Duckweeds Pondweeds	Soft muck (mixed organic and mineral)
2. Deep Marsh	Flooded until the fall when the surface may dry out or only water-covered shallowy	Bulrushes Cattails Reeds Bur-reeds	Organic and mineral muck
3. Shallow Marsh	Flooded until the midsummer but dry on surface in August	White-top Awned Sedge Smartweed Water Parsnip	Somewhat consolidated muck rich in algae and bacteria
4. Meadow	Flooded in the spring then drying at the surface but with high water table to July	Reed-grass Fowl Meadow Grass Aster, Willows Rushes	Mucky mineral (gleysol soils)
5. Low Prairie	Briefly flooded at spring melt but soon dry	Wheat Grass Tufted Hair Grass Snowberry Rose	Deep dark mineral (chernozem soils)

Table 7 - Zonation of Vegetation at the Edges of Freshwater Bodies in Southern Saskatchewan

Nature is seldom neat, so the preceding description of vegetation regularities around lake margins is somewhat idealized. In fact, mixtures of communities are as common as distinct zones. Flooding in some years or drought in others, attack by ice in winter or by animals in summer, can produce ragged shorelines where communities are reversed from the expected positions, or are lacking altogether. Ploughing, burning and grazing can also have drastic effects on the structure and composition of vegetation, and few water margins have escaped at least one of these man-induced influences. However, certain kinds of disturbance such as those caused by climatic fluctuations are actually a stimulus to wetland productivity. By putting stress on communities, and opening them up they contribute to habitat diversity, community variety and soil biochemical activity.

In terms of vegetation and animal life, the most productive sloughs and lakes in the province are those ringed with unstable, changeable meadows and marshes. Abundant moisture and plenty of nutrients from the organic-rich soil provide a good environment for rapid plant growth, while fluctuations in the water level induced by climatic cycles or the normal seasonal "draw down" create a gradient of environments for different species. In turn the productivity and diversity of the vegetation attract many animals. The shallow warm water in summer swarms with tiny organisms, the marshes and meadows are alive with insects, frogs, rodents and birds, and hunting the margins are coyotes, skunks, racoons and hawks.

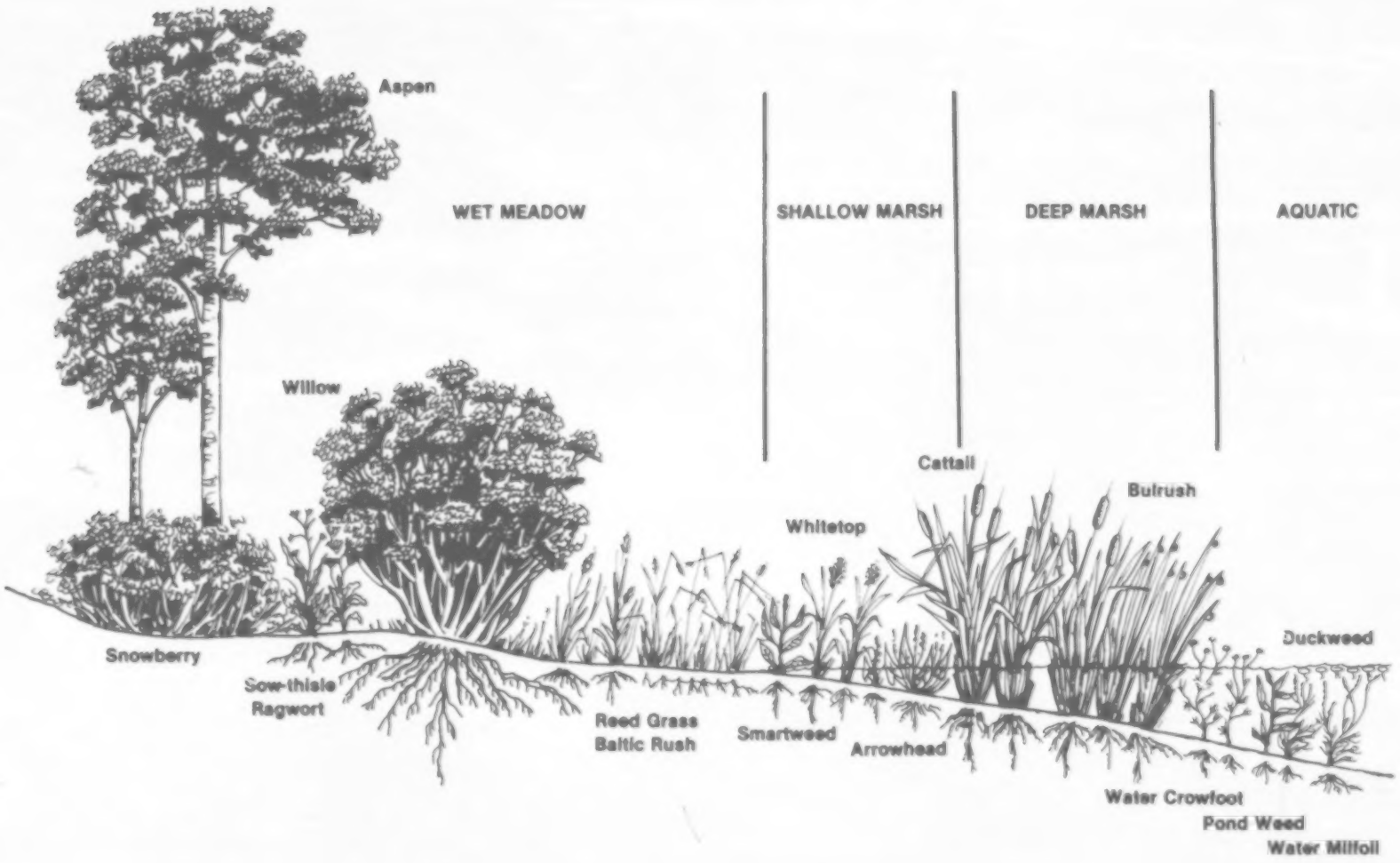


Figure 42 - Common Plants in Freshwater Marshes

Waterfowl illustrate the dependency of man and animals on the continued productivity of lakes and sloughs. The province would be poorer without its diverse and fascinating bird life: the ducks, geese, coots, grebes, loons, herons, gulls, terns and all the shore birds that return each spring to enliven the wetlands. For example, diving ducks such as canvasback, redhead and scaup need permanently inundated basins where they can feed on the tubers and nutlets of submerged plants in and beyond the deep marsh zone. On the other hand, dabbling ducks such as mallard, pintail and blue-winged teal are attracted to the shallow marshes and wet meadows where they can "tip up" and feed on organisms in the bottom ooze. They even find suitable habitat on temporary sheet water in wet years.

Later on, when the young have hatched, dabblers join their diving cousins on the more permanent water bodies to raise their broods. Similarily, a diversity of nesting sites is required for the different species. Some nest in marsh vegetation over the water while others seek tree holes or the shelter of shrubs and grasses on dry land. A good mix or interspersion of water bodies of different sizes and depths is therefore essential for waterfowl. Each species has its particular requirements for feeding, courting, nesting, loafing and, in the fall, marshalling for the southward migration. The key is wetland variety.

It has been calculated that more than 85 percent of the wetland basins in the south are small (less than 0.4 ha or 1 acre) and/or shallow (less than one metre deep). This means that they have no permanent water and are mostly in the shallow marsh and meadow categories. In dry years it is therefore easy to clear away the marginal bushes and plough them, converting shallow sloughs to farmland. This practice, combined with drainage of the deeper water bodies through ditching or road construction, is steadily reducing the province's wetlands. The ultimate effects on local climate, groundwater, wildlife and landscape variety are not difficult to predict.

(3) Saline Wetlands

Saline ponds and lakes are more numerous in the arid southern parts of the province. In the north they are rare. The chief cause of salt accumulation is the surface discharge of groundwater carrying epsom salts (magnesium sulfate), Glauber's salts (sodium sulfate), dissolved ordinary "table" salt (sodium chloride), and other chemicals dissolved from bedrock and drift. Each year the evaporation of water concentrates the salts, producing the white crystalline crusts which are often incorrectly called "white alkali". True alkali soils do occur but fortunately they are not widespread. They tend to be blackish due to the dissolving of surface organic matter by the caustic washing soda (sodium carbonate) that is present.

A number of salt plants or halophytes have adapted to living on saline soils. Because summer evaporation tends progressively to increase the concentrations of salts toward the centres of shallow basins, the most tolerant halophytes occur there. Upslope toward the basin edges there is generally a gradient of decreasing salinity where plants less and less tolerant of salts can grow. The zonation displayed is quite different from that around freshwater ponds where the patterns of plant growth are dictated by water depth and time of draw-down rather than water chemistry.

In the fall when salts are most concentrated near the water's edge or on seepage soils, the small glasswort or samphire turns red and makes a striking colour display against the white surface. It is the most tolerant halophyte, surviving where the water contains as much as six percent salts. Half a dozen other herbs associated with it also change from green to red late in the season. Next upslope are several meadow zones of salt grasses, in the lowest of which the poisonous seaside arrow grass is prominent. The outermost and highest areas, only flooded by saline water in the spring, are characterized by foxtail barley, wheat grass, cord grass, gumweed and, in the south, by scrubby greasewood.

Some of the larger saline lakes in southern Saskatchewan are Last Mountain, Wakaw, Redberry, Manitou, Little Quill, Big Quill, and Little Manitou. The listing is in order of increasing salt content. Little Manitou has a salinity of 12 percent, and it is therefore almost lacking in plant and animal life. In such waters there are only some salt-tolerant algae and brine shrimp, providing organic matter for the brine flies that swarm along the shores. In somewhat less saline water bodies, ditch grass is the only submerged plant and prairie bulrush the sole emergent. The two provide a simple diet for visiting waterfowl and muskrat.

A sequence of soils in a characteristic catena is matched to the vegetation gradient around saline basins. From wet to dry, from prairie bulrush and glasswort to salt-grass meadow, the profiles change in parallel from waterlogged (saline gleysol) to prairie-like (saline chernozem), reflecting the changing regime of water chemistry and flooding.

In addition to the soils that are associated with salty ponds and lakes, large acreages in the province are saline from surface evaporation. Summer fallowing may be a contributing cause, for the removal of living plants and their roots confines evaporation and salt concentration to the upper part of the profile rather than to the entire root zone.

Soils under the influence of excessive sodium and magnesium sulfates and chlorides tend to be soft and puffy. If, however, the surface salt concentration is partly reduced due to changes in climate, drainage or groundwater, then "solonetzic" profiles develop with hard, impermeable subsoil (B horizon) under a shallow surface (A horizon). In the arid south such soils are locally called "burn-out" soils because commonly the A horizon has been eroded in shallow pits or down to the tough B horizon. In the spring or after heavy summer rains the pits are flooded and the land seems wet, but in the intervening periods the surface is very dry and hence sparsely vegetated.

8. Man in the Landscape

For every organism there is one particular kind of suitable habitat — some part of the biosphere that has evolved to provide the necessities of resources, energy, food, and shelter. Only man seems to escape such constraints. He has spread over the continents from the tropics to the polar regions, populating the entire world. Human populations are expected to increase from the present four billion to about six billion by the year 2000. How is it that there is so much habitat for the human species, compared to what there is for an animal such as the moose?

The reason is that wherever man goes, he *remakes* the environment to suit his ecological needs. In our man-made habitat we recreate the ancestral subtropical savanna with its flat plains (level floors), grass (carpets), warmth and light (central heating and lamps). We import exotic foods from the south, and bring in an adapted flora and fauna (house plants and pets). Beyond the towns and cities we convert complex landscape ecosystems into simple ones that provide *our* particular food and fibre needs. Wherever the natural environment regimes are beyond our "range of tolerance", they are modified until they are acceptable.

But this building of the human environment and its accelerating expansion around the world is not without cost. It requires that all of the non-human world be exploited for the benefit of one species — us. Competing organisms must be eliminated so that more of the sun's energy can be channelled to an increasing human population. An ever-increasing consumption of natural resources is required to provide the food, furnishings, and piped-in comforts expected in the western way of life. In short, human cultural environments are built at the expense of the biosphere, threatening to destroy it. The pay-off for an increasing population and an increasing standard of living is clearly a decreasing quality of the world environment. When food, water, and air are tainted with chemicals, when the roar of machinery fills our waking hours, when scarred landscapes surround us, and it is increasingly difficult to find appealing natural scenery, then it is time to ask: "Is the artificial habitat alone a good habitat?"

A good habitat is one that not only provides the obvious necessities of life, but also provides for renewal, for recreation. By itself, man's artificial cultural world can do neither. The highly processed foods we eat still have their sources in the mysteries of photosynthesis and animal assimilation. The chemically treated water that we drink is still purified through worldwide atmospheric distillation. The bases of these and other life processes are rooted in the cycles of the primeval world environment. Their continued renewal depends on natural cycles susceptible to the impacts of man. We risk our future if we do not recognize the limits of our own creations and continue short-sightedly to reshape the biosphere's resources and to fill its spaces with more people and more artifacts.

The re-creational values of landscapes apply not only to biological and physical resources, but also to man himself. There is increasing evidence that a basic source of intellectual and artistic creativity comes through exposure, as children, to the living, out-of-door world. Such early experiences are inspirational and strike deep psychological roots. In later years, adults draw on them and return to them in memory or in fact, for recreation. On the other hand, the psychological effects of at least some parts of the built environment are questionable. In the "zoos" of city centres, cut off from natural landscapes, people are apt to behave strangely, like animals cruelly caged. A good habitat for man has to be open to the biosphere. It must strike a balance *in size* between man-made cultural constructions and the supporting biosphere ecosystems.

How can the factor of size be gauged? What population size is "enough" for the world or, to come closer to home, for the province? What is a safe carrying capacity? At first sight Saskatchewan seems to be in good shape, with only a million people occupying one quarter million square miles. But remember that the population is not evenly spread; the north is virtually unoccupied while most people live in the south. Furthermore, pressures on the province's environment are not due to the resident population alone but to those who come in temporarily for such purposes as fishing and hunting, as well as those who never set foot in Saskatchewan yet determine the uses of the land by offering money for its products. If the province's farms are providing food for 50 million people around the world, then the environment is being treated as if 50 million people lived on it, except that they give back no fertilizer to restore the soil! A small population with energy-intensive machine technology, striving to increase the land's economic yield, presses just as hard on landscape ecosystems as a large population that achieves the same productivity.

This means that *numbers* of people are no longer a good index of the stresses placed on environment. A small population is not necessarily a sign that a good balance has been achieved between human habitat and the biosphere. A better index is *energy use* within any area of interest because it is through energy from fossil fuels and electricity that the biosphere is reshaped by man. Energy is used to produce and drive machines that not only rearrange the face of the earth but also throw off wastes. No energy-using technology is possible without the production of garbage and pollutants as by-products. In this, machines are like people, consuming highly organized fuels and giving off lower-order wastes.

It has been estimated that each Canadian uses about 50 times as much energy a year as an individual in a "developing" country such as Bangla Desh. Therefore, in energy terms Saskatchewan's population is the equivalent of 50 million people operating at a lesser technological level. Because energy use has been doubling about every 12 years, our "equivalent population" pressing on the provincial environment will be even larger by the end of the century! From an environmental viewpoint the south of the province is over-populated now. The pressures and impacts are bound to worsen even if the head-count population of Saskatchewan declines, and this seems unlikely.

The problem is this: How can we maintain good landscapes and healthy environments in the face of current powerful pressures to convert all lands to people habitat or at least to people-serving habitat? Increasing difficulties of maintaining a balance between population, machine technology and the biosphere's landscapes lead directly to a necessity for planning.

V. The Use of Land

1. Introduction

The biosphere is the thin, life-filled layer at the earth's surface. It is man's immediate environment. Its major parts are the air stratum above, the landforms and water bodies below, and the living organisms sandwiched between. The general term for this environment life-filled space is **land** and the name can be applied to small or large areas, from a hectare of the earth to a continent or the world. "Landscape", "landscape ecosystem" or "terrain" are variations of the term; they carry the same inclusive meaning as "land" but are mostly used with reference to local areas. A primary question that concerns man's quality of living and ultimately his survival is "How shall this precious world environment, the land, be used?"

Homo sapiens evolved in the biosphere, as a small part of it, one kind of organism among many that soak up sunlight and draw other necessities from the surrounding matrix of air, earth and water. The planet has produced and nourished *all* life as we know it. If not tampered with too drastically, it will continue to do so until the sun burns out some billions of years from now. We humans, on the other hand, can do nothing without the earth's environment. We cannot live, let alone create, without its moment-to-moment support. Some philosophers even suggest that it is incorrect to think of ourselves as separate from surrounding nature. Every organism, each one of us, is really an organized or focused "point" of the environment and therefore, in the words of Alan Watts,* "the world is your body". Despite the ecological truths in these ideas, they are not yet accepted because they are not generally understood. Man continues to act as if he were independent of the biosphere, unaware of his complete dependency on the complex self-renewing ecological system that he so often treats carelessly.

Unawareness of dependency is dangerous because it leads to misplaced values and wrong priorities. Today man values his own well-being far above the well-being of environment. Many people sincerely believe that unless each part of the land environment is contributing first and foremost to the needs and comforts of humanity, it is being wasted. So the biosphere — the living environment — is not seen as the source and support of life itself, but as a "resource" to be harvested and processed as rapidly as possible in order that national populations and economies can grow without limit. When a higher value is placed on the one part (man) than on the whole (biosphere) and an attempt is made to force the whole to serve only that part, disaster looms. Every continent and country now shows evidence of the creeping destruction of environment, brought about by the past misuses of the land and of its "resources".

If the land of Saskatchewan is to be well managed, its essential role for the health and sustenance of all life must first be recognized. The province is an important part of the world environment, and we who live here and are its caretakers for a short time must accept responsibility for its preservation. A basic problem up to now is that our main goal in land management has been the short-term improvement of human conditions. To this end we have fostered whatever activities would maximize dollar income. Rather, the goal must be the long-term maintenance of environmental health and beauty, whose by-product is dependable productivity and human enjoyment. "Conservation" must be redefined to this new ecological meaning.

* Watts, Alan W. 1966. *The Book (on the taboo against knowing who you are).* Collier Books, New York.

2. Conservation, Old and New

The old idea of "conservation" is equated with "wise use", the wisdom being that of the developer. It is based on the traditional western view of Man as an Economic Animal in pursuit of profit and wealth, subduing Nature and wresting resources from her. It has been thought that such self-interested activity, pursued by free men with a minimum of state control, will contribute to the common good and to progress. To round off the argument, "progress" is defined as economic growth, measured by the quantity of goods and services produced by society. In this view, as long as provincial and national economies are growing, all's right with the world. Indeed, we consider that the prime function of governments is to keep the economy growing.

Within such an ideological framework, "wise use" of resources has one primary meaning — maximizing economic returns. For non-renewable resources such as oil, coal and potash it implies the avoidance of waste by extracting every last bit from each well or mine. For renewable resources such as agricultural crops, forests and fish, it means not only efficiency in extraction but also the goal of increasing productivity by whatever means are at hand — making two blades of grass grow where one grew before. These ideas have been so firmly implanted that they have acquired moral overtones. To develop resources is God's will, and to neglect to develop available resources is a sinful waste! These are the attitudes that have governed our treatment of the land. The result has been a continual degradation of the biosphere.

Some years ago, events began to challenge the traditional approach to resource use. It became clear that rapid economic growth caused environmental problems. Prime living space filled up with sprawling housing developments, industries and highways, with their accompanying ugliness, smog and noise. The realization dawned that the earth is finite and that sooner or later the growth of populations, produce, and garbage must be slowed and stopped. Freedom on the part of each citizen to pursue his own economic self-interest was also seen to cause environmental problems.

In cities, the chaotic results of various developers operating without reference to one another, or to any overall social plan, were visible. Again, the rule of economic efficiency, or "cheapest is best", caused desecration of landscape beauty as well as massive pollution of air, water and soil. "Wise use" meaning "efficient development" was just not good enough.

Environmental thought in the last two decades provides a more realistic foundation for "conservation". Man is no longer viewed as primarily an economic animal, but as a social and ecological one in search of his humanness, living by necessity within nature, and adapting by culture and lifestyle to the requirements of the biosphere and ecosystem stability. From this perspective, human activities must be guided by a sense of stewardship before self-interest, and by the recognition of the suicidal potential of species self-centredness. He must also take responsibility for environmental protection, and surrender some individual freedoms.

Progress can no longer be equated with blind growth, but rather with those activities that move humanity towards a creative symbiosis with the earth. A prime function of government must be to foster harmony between man and the land.

Within such a framework, "Conservation" (spelled with a capital "C" in its new meaning) becomes the wise maintenance and, in degraded areas, the improvement of the world environment. For non-renewable resources it implies overly cautious, miserly use. This is essential to protect environment and also to safeguard some irreplaceables for the needs of the future. As to energy, Conservation suggests increasing reliance on that which flows daily from the sun, and a tight rein on biologically dangerous sources. For renewable resources, it means harvesting only what each healthy recycling system can safely continue to produce, with wariness of "forced growth" techniques and their often dangerous side effects.

The goal of Conservation is to achieve a rational balance between human populations and the ecosystems they occupy and depend on. It is also to keep man in touch with the world of nature where he evolved and to which each of us is linked physically and spiritually.

3. Broad Aims of Land Use

How land is used depends on what its "owners" see in it and value it for. Is land merely a source of resources, a means of production? If the answer is "yes", then it will be treated only as an economic commodity whose uses are determined by prices in the market place. It will be "conserved" in the "wise use" way of maximizing money returns. But there will be little affection for it and man will be alienated from it.

If, however, the land is seen as landscape ecosystems and it is valued as part of the biosphere, as part of the magical system in which life evolved and still continues to be born and supported, then a more generous attitude will be brought to its uses. The land will possess its own worth and its own rights quite apart from man's. It will be sacred in the sense that it makes its own claim to be secured against violation, protecting us as we protect it. Conservation will be appreciated as the development of careful and sensitive relationships between man and land.

What does such a re-evaluation of land imply? It implies that, for those landscapes we control, the uses should be guided by the goal of maintaining the land's *health, beauty, diversity, permanence* and *productivity**. All are related; each requires attention to the others.

When land or landscape ecosystems are *healthy* they are resilient and have a good ability to cope with stresses and to recover. Just like our bodies when they are functioning well, each part is doing what it ought to do in the service of the whole. Recycling mechanisms are working smoothly, so there are no bottle-neck "pile ups" of unnatural pollutants, no cancerous growths. This kind of health in the landscape is recognized intuitively by its beauty and productivity. But man frequently makes landscape ecosystems unhealthy by overstressing them. Forced productivity, with massive injections of energy and materials brought in from outside, and overloading with wastes that are slow to break down, are two types of stresses. Then the systems lose their self-maintenance abilities. Frequently an early sign is a loss of water purity in soil, wells, streams and lakes. Toxins in water and air often result in secondary sickness in the organisms that depend on them. In extreme cases, as in some mining areas where sulfurous gases are released, the vegetation may be poisoned, resulting in extreme soil erosion.

Protection of *beauty* in the landscape is allied to the maintenance of health. Although beauty is said to be an individual preference, existing only "in the eye of the beholder", this is not really true. We all share common general standards of beauty, preferring green landscapes to moonscapes, fresh air to smog, and clear to muddy water. The reason we call what is healthy "beautiful" is rooted in our racial history. Our ancestors evolved in the natural world and were necessarily adapted to its ecology. As their descendants, we are still children of the earth. Our sense of beauty in nature reflects a deep intuition of what is good for us, of what is a "fit" environment. On the other hand, ugliness signals those things that are against life and are "unfit" for it. Therefore, the sense of beauty is one useful guideline for what is ecologically right. Usually our intuition is correct. When we are affronted by scars on the landscape, such as construction

* Schumacher, E. F. 1973. *Small is beautiful.* Blond & Briggs, London.

bulldozed straight through terrain with no attention to contours, widespread devastation of green plant cover, garbage heaps, etc., there *is* something radically wrong in the land use. The beauties of forests and grasslands, unscarred valleys and hills, well-kept green farms, clear streams, all proclaim that conditions are right for life.

Diversity is another dimension of health and beauty. Such expressions as "Variety is the spice of life" and "A change is as good as a rest" suggest that too much sameness is a bad thing. Diversity is, of course, essential to man's well-being because we need a variety of things from our environments. The most pleasing landscapes are those where there are contrasts of landforms, water bodies, vegetation, animals. We seek such areas on our holidays, forsaking the monotony of module-built cities and towns in order to get back to the natural landscapes and be "re-created". This is the root meaning of recreation. Unfortunately, land uses that are efficient in the sense that they produce most for the least cost almost always destroy diversity. It is easier, faster and more profitable to plough up shallow sloughs rather than work around them. Simplification of landscapes by cultural activities is a major cause for alarm on Saskatchewan's south lands. A little thought will suggest that the technological efficiency we are all taught to prize runs counter to life's more important diversity, beauty and health.

Permanence of the land is what we have been discussing. There is the additional implication that protection and maintenance of environment are long-term aims. It used to be thought that continual growth in the rate at which we change resources into consumables was a sure sign of progress. Now there is rising doubt. True progress lies in developing better, more sensitive relationships with the world environment, so that there *will* be a future for humanity. Granting this, then the same values that we perceive in landscapes today must be projected as goals into the future. The health, beauty and diversity of scenic landscapes, interesting landforms and streams, the myriad forms of butterflies and birds, fish and land animals, are all permanently good and should be so considered in plans made for the future uses of land.

Productivity refers to the rate at which useful products of the land are made available, such as plant crops, animals, water, etc. Man has always been interested in this property of land, recognizing the differences that exist from place to place depending on climate, soil and organisms. Much applied science today is devoted to the single purpose of increasing yields. It has not been widely recognized, however, that productivity in the long run is a function of the permanency of ecological relationships reflected in the land's health, beauty and diversity. If the importance of the latter are clearly appreciated, and as ends they are firmly established in policy, then and only then can productivity be safely pursued. History is full of disastrous stories of attempts to maximize productivity apart from the controls that guarantee permanence of landscape ecosystems. In this regard, a serious threat to Saskatchewan lands is the developing world shortage of food and fibre. In the rush to profit from these scarcities, there is a danger that increased productivity may become the only aim of land use. When southern Saskatchewan is wall-to-wall wheat, will it still be a good place in which to live?

4. The Need to Regulate Land Use

Every landscape seems to have a character of its own, impressing on the observer its particular "feeling". In Roman times this was called its *genius loci*, the spirit of the place. Where scenic beauty or awesomeness made the *genius* particularly impressive, the place was often treated as sacred and a shrine was erected. Today we may dedicate such landscapes to recreation and erect natural history museums or nature centres.

The idea that each kind of terrain has its own *genius* is sound ecology. Some places should not be touched by man, or touched only carefully. They may have a unique "atmosphere" and uplifting impact on the human spirit, or they may provide a protective function such as harbouring wild animals and unique landforms, or serve as collection

areas for freshwater springs. Some places can safely be used for certain purposes but not for others. Stony and sandy soils lend themselves to the grazing of cattle but not to the growing of cultivated crops. Again, there are some kinds of land that seem "made for" a particular use, such as the flat, fertile lake-bottom clays where cereals grow so well in the province.

Nevertheless when we look around there are many places where the *genius loci* has been ignored. We see roads slashed through attractive valleys with no attention to aesthetics. We see communities and their structures built on river flood-plains where society pays the price of stupidity when the inevitable floods come. We see cultivation on steeply rolling land, and on stony soils which leads to water and wind erosion of the top-soil. Cities expand over choice agricultural soils while better building sites nearby are ignored. What are the reasons for such obvious misuses?

There is no simple answer. Poor land use is, in part, a heritage from the past when, in different circumstances, many present problems were initiated. Most cities and major towns were founded beside streams on agricultural plains. Much larger now, and still growing, these settlements spread over good farmland and encroach on the water. Ignorance of the earth's processes accounts for some misuses too, for example where unstable slump-blocks along valleys are used for building sites. Some errors are the result of many people doing small, seemingly insignificant things that together add up to a big problem — such as landowners draining their sloughs into the grid-road ditches, thus increasing spring run-off and contributing to floods.

The short-term viewpoint that permits ploughing and seeding sandy soils in moist years can contribute to environmental troubles over the long run. Taking all of these into consideration, the chief causes of misuse can be traced to short-term economics. It often *pays* the individual to misuse the environment. In the absence of protective regulations, there is money to be made by grazing more cattle than the range can support over the long term, by cutting more trees than are planted, by catching more fish than are stocked, by using the streams for sewers rather than recycling the sewage, by mining gravel without reclaiming the pits, and everywhere treating the land as only a means to the all-important end of economic profit. Therefore, clearly stated regulations are needed to discourage land use practices that are destructive, while encouraging those that protect and conserve.

Misuses will not cease until there are widespread changes in thoughts about land. The "inscapes" of our minds must be sensitively tuned to the landscapes around us. From better understanding, more sympathetic treatment will flow.

The purpose of this book and the accompanying Landscape Guides is to convey a perception of the land as an organized functional part of the biosphere to which we are tied by life and culture. The local landscapes of the province, developed on their glacial, proglacial and postglacial landforms, provide an understandable starting point. For each the aim should be to catch its *genius loci*, to glimpse something of how it was formed and what it is today and to appreciate the relationships of its parts as well as its role in the wider region and province. Understanding and appreciation will help to develop a feeling for the land, an empathy with it, and intuitions of its intrinsic worth. Then careful uses will come of themselves.

5. Guidelines and Goals for Ecological Land Use Planning

Once we have recognized the major aim of land use to be an improvement of the man-land relationship based on care for landscape health, beauty, diversity, permanence and productivity, and having also recognized that such earth care will not come about without effort on our part, including certain restraints on bad land use, some guiding rules and goals can now be proposed. The ten suggestions that follow, with their explanations, are far from an exhaustive treatment of the subject and are meant to draw attention to and illustrate the ecological approach to land use planning.

i) Fit man's activities to what the land can safely sustain indefinitely.

This is a very general but fundamental guideline and all the other suggestions are really variations of the same theme. It emphasizes that the goal of ecological land use planning is the protection of land ecosystems. It places the first priority on the land's ecological necessities, ahead of people's needs.

ii) Avoid major irreversible commitments; plan to maintain future flexibility.

The planning of land use has to be a continuing process, not a once-and-for-all exercise. There should therefore be a constant awareness of the need to keep options open for the future so that there will continue to be opportunities for choice and "escape routes" when conditions change. This means conscious avoidance of large commitments of land (soil and water) to uses that are not easily reversible and that therefore close the door to future flexibility. "Big is dangerous." Examples that come to mind are the commitment of key resources such as water to political regimes over which we have no control (by inter-basin, out-of-province transfers), or the destruction of fertile agricultural soil by allowing steady over-growth by industries, transportation facilities and cities.

iii) Develop comprehensive land use objectives and plans for the largest areas before the smaller regional and local ones.

Because small land ecosystems are parts of the larger surrounding ones, plans that seem reasonable at a number of local levels may not fit together (or may defeat one another) at the larger regional level. Similarly, land use plans developed at the regional level may not make sense from the still larger provincial perspective. As an example, the draining of sloughs in a rural municipality may apparently make good sense for the farms involved, but in the larger, more inclusive drainage basin, it may cause adverse water-table changes and flooding. Similarly, planning to let a city go on expanding rather than to build up small adjacent centres may make good sense from the viewpoint of the city fathers, but it may be wrong from the larger provincial viewpoint. In other words, what seems good for the part may not necessarily be good for the whole. Therefore ecological land planning has to start from the largest possible area, establishing first a wise long-term balance of uses from the broadest possible viewpoint so that regional and local plans will *nest* consistently in the overall framework and contribute to it. The alternative is a patchwork of conflicting plans and programs from which environment is the loser.

iv) In sudividing the province for planning land use, choose ecologically significant units.

Any major land use plan, for example one for the entire province, can be little more than a statement of objectives and a listing of priorities. It is the regional and local parts of such a plan that actually deal with the problems of particular land areas. At these lower levels, the units of land that are chosen should have as much environmental homogeneity as possible; that is, they should be natural geographic units. For example, the Shield country in the north of the province is obviously different from the sedimentary rock country in the south and the land use problems are entirely different too. Water-shed basins are particularly useful planning units because activities in any part can alter the water regime in other parts. Life Zones and the smaller landscapes they comprise are also worthy of attention as framework elements for the planning process. On the other hand, rural municipalities and such legal-political subdivisions are poor as planning units because their boundaries have been set without reference to terrain. To use them is to risk planning against nature rather than with her.

v) Within large ecological land units, establish sub-areas suitable for particular primary uses.

Before discussing some of the primary uses, it needs emphasizing that land areas cannot be expected to support all uses. There is a term "multiple use" that suggests that land can be all things to all people, and that particular areas can serve

at one and the same time the different needs of mining, ranching, trapping, hunting, forestry and parks. On closer examination, the only sensible interpretation of "multiple use" is that, for each area, there be one designated primary use to which all others are fitted, *if they can be*. Without this constraint, multiple use makes land a commons where all are free to dip in and take, but where there is no clearly assigned responsibility for Conservation. By identifying the ecological characteristics of landscapes, some assistance in selecting the most suitable of the competing demands is given. Responsibility can then be placed on one appropriate user group to "mind the shop" and husband the land resource.

Obviously it is impractical to assign single uses to very large land areas. Often the many needs of society have to be rationalized within regions or smaller landscapes. One technique that maintains the primary use concept is zoning, whereby the large area is subdivided and the parts are assigned to agriculture, forestry, recreation, wildlife, industry, housing. The essence of environmental wisdom is to strike a balance between diverse uses, intermixing them in space and varying them in time.

vi) Plan a healthy mix of major land uses and wildlands.

A simple classification of major land uses recognizes three classes to which "non-use" (wildlands) is added:

a) **Urban-Industrial**, comprising all high-energy use and dense population areas of towns, factories, mines, etc.
b) **Intensive Agriculture**, comprising farmlands with moderate energy use and moderate populations, where domesticated crops of plants and animals are raised for food.
c) **Extensive Culture**, comprising the low-energy use and low population areas that support ranching, commercial forestry and fisheries, trapping, park recreation, etc.
d) **Wildland**, comprising the largely uninhabited wilderness and natural areas maintained by natural (solar) energy with few inputs or extractions by man.

Land use plans sensitive to environment must aim at maintaining or restoring a balance between these four categories of land. In the first two, man dominates nature by his works, frequently creating environmental problems. In the last two, nature dominates man's works; the normal cycles carry on and there are few or no problems. Within major land planning units, sub-areas or zones with their designated primary uses need to be combined spatially in such a way that the restorative effect of natural processes is maximized. A flexible goal should be set within planning areas for the proportions of land devoted to each of the four categories. A good exercise is to calculate what the proportions are and what they should be for any given region.

vii) Decentralize urban-industrial land use and accent recycling

Urban-industrial use of land is ecologically the most drastic and at the same time the most difficult to control because of the potent combination of population, wealth and power. Cities and their associated concentrated industries draw energy and material resources from the surrounding lands and throw off massive amounts of waste that have to be disposed of in air, water and soil. One planning control is decentralization. This keeps the urban-industrial complexes at a reasonable size by scattering them through the other land use areas where their impacts can more easily be absorbed or dispersed. This means planning against the concentration of people and industry, energy and garbage in a few large cities.

Within all urban-industrial areas, the only reasonable solution to pollution seems to be the recycling of waste materials; the re-use of metals, glass and paper, and the return of sewage and garbage as fertilizer to the land. The ultimate goal is "no free release" of toxins and other materials that are not quickly degradable, otherwise the adverse effects of this one land use on all the others will persist and increase.

Another alternative, discussion of which is just beginning, is the replacement of "hard" industrial technology that is energy-intensive and produces dangerous wastes with "soft" technology that uses safer energy sources and produces biodegradable wastes. This proposal is part of a revolutionary theory that the goal of industry should not be to replace labour with machines, but to provide labour with the kind of intermediate technology that makes it more productive. The implications also point toward decentralization, planning small cities, and encouraging local self-reliance in the production of food and other necessities. Such ideas make ecological and cultural sense.

Because problems of deteriorating living conditions and pollution appeared long ago in cities, something can be learned from their attempts at land use planning. Cities have recognized the importance of zoning for different priorities, such as separating residential from industrial areas. However, they have seldom taken the next important step of bringing the different use-zones together in such patterns that the worst features are ameliorated. Cities have not been champions of decentralization, nor have they tackled the spatial integration of job areas, homes, shopping and recreation centres. Some of the unfortunate results are lack of "escape terrain" near the city centre, twice-a-day traffic congestion and air pollution, and general frustration in the daily lives of the inhabitants. In short, the lack of city planning has reduced the quality of life without even a compensating economic gain.

viii) Maintain a diversity of terrain and crops on intensive-agriculture lands.

The intensive agricultural use of land is Saskatchewan's primary source of wealth. Farming is the basis of the economy. The result is that most of the south of the province, the "grain belt", is devoted to this one use. With the land already committed, there remains little flexibility for other uses. Nevertheless a few goals can still be pursued which, if attained, will prove their worth in the future:

a) In the south there should be no further conversion of native grassland, brushland and valley woodland to cropland, for the relatively small amount that remains is vital for wildlife habitat, recreational uses and landscape beauty.
b) Terrain diversity should be maintained on farms, with particular attention to the rarer glacial landforms such as eskers, and to wetlands, sloughs and lakes.
c) Greater use should be made of crop diversity and crop rotations in the interests of soil conservation and the biological control of insect and weed competitors.

How farmland is used is, of course, the owner's responsibility, but the same ecological concepts brought to the other kinds of land use are applicable. As in the urban-industrial lands, recycling of wastes, utilization of "soft" or low-energy technology (such as windmill generation of auxiliary electricity), and care in the use of chemicals and toxins will contribute toward keeping the farm environment healthy and productive. However, those things that need to be done become increasingly difficult and uneconomical as farm holdings expand and ever-larger machines replace people on the land. Just as there are sound ecological arguments for limiting city size, so farm size should perhaps be limited in the interests of careful land management.

An important point not widely appreciated is that dryland agriculture is a recent enterprise, not only in western Canada, but in other parts of the world as well. This means that there is nowhere a history of successes and failures to provide guidance today. *No one knows whether the productivity of Saskatchewan lands under current management practices is sustainable.* A careful, conserving and questioning approach to farmland use is absolutely essential.

ix) Preserve the renewable capabilities of extensive-culture lands.

Extensive-culture lands usually represent a fairly safe compromise in the man-land relationship and one that can last for a long time — with care. The technology of ranching, forestry, fisheries and trapping, though quite sophisticated, is mostly of

the low-energy input type. The crops are produced by the sun's energy, there is little attempt at "forced growth", and human population pressure is low. To be sure there are always local intensive-use areas such as corrals, wood camps, recreation centres, fishing and hunting camps, but they are not really important and good management moves them around to prevent permanent damage to terrain. The chief problems are the pressures that build up, especially when the prices are right, to convert these lands to more intensive uses; to plough the rangelands, to make community pastures of the forests, to expand the lakeshore tourist facilities.

It is important to recognize that extensive-culture lands, a compromise between intensive use and preservation, have long-term values just as they are. Such ecosystems will continue to be productive and beautiful forever with little effort on man's part. They are also "money in the bank" for an uncertain future; their maintenance, along with wildlands, will keep many options open for the evolution of our lifestyle and of our descendants' culture.

x) Protect all landforms and their landscapes in wildland preserves.

Like the extensive-culture lands, wildlands may also be thought of as "money in the bank", saved for an uncertain future. They are genetic pools, outdoor museums, research areas and a national heritage for cultural and aesthetic appreciation. But they are much more than utilitarian. Preservation of wildlands is the surest sign of a sensitive appreciation of the need for earth care. Thus the conscious preservation of wildlands is the mark of an ethical civilized society that recognizes both its ecological roots and the values of the planet's natural forms quite apart from man himself.

The goal for wildlands is complete preservation — "No use that mars," or "No use is good use." The fitting slogan is "Let it be." Therefore, on areas recognized as representative of wildland terrain there should be no exploitation of resources, whether renewable or non-renewable. In particular, all wild animals should be protected and prized as a mark of respect for the biosphere and perhaps as some atonement for those species that civilized man has needlessly hunted to extermination.

Areas of many sizes and characteristics can qualify as wildlands, so long as they retain the primeval character. They can include everything from the "fragile" small environments, such as groundwater spring swamps and colony-nesting bird islands that need nearly complete protection, to large robust wilderness areas that so far have been preserved only in National Parks. Intermediate in size are a variety of reserved natural lands, some with specific uses and others of the "no use" kind, that include the Provincial Parks (for recreation), Wildlife Reserves (for protection of birds and mammals) and Natural Areas (for protection of landforms and organisms in the interests of education and scientific study).

Additional examples of goals and guidelines for land planning could be suggested; for example, the need to integrate the uses of underground water with the surface practices that both affect and depend on it, or attention to the importance of roads and other transportation corridors as means by which certain land uses can either be encouraged or discouraged. However, the ten that have been commented on are perhaps sufficient to illustrate the ecological approach which, by fostering healty interrelations, aims at balance and stability between man and the land. To some people "stability" seems a wishy-washy goal whose achievement would turn the world into a dull place. The interpretation is wrong because, by its nature, biosphere stability is dynamic and evolving. There will be no lack of excitement in pursuing such a goal.

One final important point deserves attention. It is obvious that a good understanding of the land, plus a trustworthy base of information, provides the necessary ground for planning. For example, if prime agricultural land is to be protected from

encroachment by other uses, or if significant wildlands are to be preserved, then there must be an inventory of the Saskatchewan terrain. Fortunately, much useful work has already been done on the geology, soils and forests of the province. A beginning has been made on an inventory of possible natural areas and related kinds of wildlife and recreation reserves. A great deal of information has been collected on water bodies and on the resources of watershed basins, particularly in the south. For the same region, many Canada Land Inventory maps have been produced, indicating the potential of lands for agriculture, forestry, wildlife and recreation. An excellent summarization of geographic knowledge for the whole province can be found in the *Atlas of Saskatchewan.*

However, the various inventories are incomplete and furthermore they have seldom been related to one another in ways that facilitate ecological land use planning. The idea of defining landscape ecosystems as the geographic units to which all specialized knowledge of geology, soils, vegetation, wildlife, water and land use practices are related has not been put into practice. Therefore, further integrated studies of the province's terrain will be required in the future. In this there is a great challenge for young people to blend their concerns for Saskatchewan's future with enthusiasm for outdoor geographical and ecological studies.

6. Impediments to Land Use Planning

It is one thing to set high goals for creative use of the land but quite another to act in their pursuit. Very often the things that ought to be done in this world remain undone because of tradition, ignorance, unconcern, selfishness, greed and all the other human shortcomings for which the excuse is, "That's human nature and you can't change it." Such pessimism is unwarranted, for there is nothing more certain than that people are capable of drastic changes in outlook when both emotion and intellect are touched. The *emotional* conversion to feeling that the world is sacred and entitled to be so treated seems to come "naturally" when young people, guided by sensitive adults, are exposed frequently to the beauties and mysteries of nature. The *intellectual* conversion comes from reasoned arguments, allowing the realities of the biosphere to indicate what ought to be done. Having discovered and understood the rules that make for beauty and permanency in landscape ecosystem, we undertake to guide our actions by those rules.

It should, however, be recognized that several hundred years of the development philosophy in the western world have put formidable obstacles in the path of earth care and rational land use. We have inherited a deep-seated mistrust of the natural world. The reason is that in the past, much more than today, life was a constant struggle against starvation and deprivation. Thus science, in its beginnings three centuries ago, was seen as a means of releasing man from the tyranny of nature, as a technique of discovering nature's laws so as to gain the upper hand over her and control her. At the same time, there developed the philosophy of liberalism on which our political and legal institutions are based. It placed complete faith in progress and liberty, including freedom of the individual to shape the world to his purposes. In this tradition, John Stuart Mill declared it man's duty to alter and transform the natural world, thus "improving the spontaneous course of nature". The message was understandable for that stage in man's history, but now we realize its dangers when carried to extremes.

In the very process of altering, transforming and controlling nature, man has cut himself off from his roots in the world environment. Today's culture is centred on cities and machine technology, an artificial man-made world. The experience that comes to each of us daily within the town and city environment blanks out most signals from the surrounding biosphere. What urban-dweller can get excited about stories of soil erosion and excessive runoff when his food does not seem to have anything to do with either? It comes, prettily packaged, off the shelves of supermarkets! In a similar way, the everyday values of individuality and competitiveness

speak louder than those of ecosystem symbiosis and cooperativeness. When the worth of persons is measured by their ability to understand and use abstract symbols and complex machines rather than their ability to keep the garden growing and the air and water fresh, then the biosphere may be threatened by an inability to be responsible, honest and unselfish toward the living system we share with other organisms.

The self-centredness of the human race ("anthropocentrism") is yet another problem that makes it difficult to come to harmonious terms with the larger world ("biosphere-centrism"). Environment will come out second best, as a means to man's goals, so long as he pictures himself as lord of the universe. Most of what passes for land planning today is the attempt to find, by environmental manipulations, the solution to human problems that properly should be sought within society itself. Conventional wisdom says that more people and more machine technology are good. When the growth that results from this philosophy begins to cause problems, then land use plans must be instituted to accommodate the increasing pressures. From a biosphere view the real solution is a change in human behaviour. We need to make fewer children and reduce the size and energy use of machines, so that both can be accommodated on the fixed land area without stress. Very soon it will become clear that a responsibility to the biosphere must confine the right of parents to have no more than two children, and to use only low-energy machines.

The organization of our society contains many obstacles to good husbandry of the land and safe planning for its uses. A key example is the idea of private property. We have the *right* to own and use land, but we are not *required* to take care of it while it is in our control. To sell land to the highest bidder without concern for the use planned for it is considered "good business" rather than irresponsibility. Furthermore, governments and educational institutions are not well organized to deal with the complexities of the land environment. As the name suggests, "departments" are to deal with parts and not with whole ecosystems. Departmentalized know-how and knowledge are as likely to cause problems as to find solutions.

Finally, our society today is unsure of its directions. Perhaps with an intuition that something very wrong is going on, people are uneasy and worried about the future. There is a suspicion that the age-old goal of material well-being is not enough. Self-centred man looks in vain for a new horizon. In these circumstances, we continue to do more and more strenuously what worked so well in the past — exploit, develop, grow. But the problems only deepen.

In this manual I have tried to suggest that the new horizon is all around us; it is the ancient horizon of the earth seen in a new light. An exciting goal can be found in the understanding, care and enjoyment of the world, a goal that leads away from the infatuation with ourselves, our artifacts, our ingrown cultures. In the search for a satisfying man-land relationship, based on an affection and respect for the land, there are great opportunities in Saskatchewan.

"It is possible, nevertheless, to assert one criterion by which all the manifold attempts at therapy (for an ill society) may be judged. Do they help men to find that nature is good? Human excellence can be discovered only by those who are able somehow to assert the beneficience of nature." ... George Grant.

VI. Glossary

alluvium: Sediments deposited by running water. Cf: **valley fill.**

apron: Blanket-like deposit formed at the base of a slope, often by the lateral coalescence of alluvial **fans.**

aquifer: A water-bearing geological stratum.

backswamp: A low wet area on a **floodplain** behind a **levee.**

biosphere: The world **ecosystem**; the life-filled "skin" of the globe's surface consisting of the air layer, the earth and water layer, and the organisms sandwiched at the interface.

biota: All the kinds of organisms of an area including micro-organisms with the larger plants and animals.

bog: Acid organic terrain formed by peat mosses and characterized by a surface cover of evergreen dwarf shrubs and black spruce.

catena: An association of small (mini) **landscapes** that are fitted to the different slope facets of a particular **landform.** The term means "chain", each of the mini-landscapes being a "link". First applied to describe soil associations it is usefully extended also to local climates and biotic communities; that is, to the components as well as to the total landscape.

channel bar: A sand or gravel bar (island) in a stream.

chernozemic soil: Grassland profile usually characterized by a brown to black Ah horizon and a columnar B.

colluvium: Sediments deposited by sheet erosion and gravity creep along the base of a slope.

community: The associated organisms within a particular geographic **ecosystem.**

conservation: The preservation and maintenance of the world environment (**biosphere, landscape ecosystems, land**); fostering a permanent symbiosis between man and land.

coulee: A steep-sided valley cut out by a glacial river but now dry or occupied by a small intermittent stream.

delta: A flat-topped alluvial deposit formed at the mouth of a stream. Exposed in gravel pits, the sand and gravel beds dip at about 30°.

dolomite: Magnesium carbonate rock; a frequent erratic in the south of the province. Cf: **limestone.**

drift: A general term for mixed sediments deposited by ice and by meltwater. **Unstratified drift** is deposited by ice and is called **till; stratified drift** is deposited by meltwater.

dune: A hill of sand, usually grouped with others (**dune field**). According to shape and orientation to the wind, dunes are U-shaped (parabolic), crescentric-longitudinal or hummocky.

ecology: Study of the interrelationships of parts and wholes; commonly the study of organism-environment (organism-ecosystem) relationships.

ecosystem: A general term meaning any inclusive system of which organisms are parts. The **biosphere** is a large ecosystem; **local landscapes** are relatively small ecosystems. The term **landscape ecosystem** is redundant but is used for emphasis. Cf: **environment.**

environment: The larger system of which any object of interest is a part. Landscape ecosystems are the immediate environments of native plants and animals. The biosphere is the largest environment over which man exerts control.

eroded till plain: A low-relief moraine scoured by meltwater with a consequent surface concentration of stones and boulders.

erratic: A relatively large rock that has been transported from its place of origin, usually by ice.

esker: A sinuous ridge formed by water running through fissures or tunnels in a glacier, usually consisting of roughly sorted sand and gravel. Cf: **stratified drift.**

evapotranspiration: The sum of evaporation from soils, water bodies, etc., plus transpiration from living plants.

facet: A particular slope feature of a landform, such as knoll top, upper slope, mid slope, lower slope. The association of facets along the topographic slopes of a landform is a **catena.**

fan: A gently sloping fan-shaped mass of sediments, often deposited where a side stream enters a broad valley. Syn: alluvial fan.

fen: Mildly acid organic terrain formed from water plants, especially brown mosses, and characterized by a surface cover of sedges and willows.

flood plain: The level bottomlands bordering a stream, susceptible to flooding during periods of high water.

fluvial: Having to do with running water (**alluvium** has a fluvial origin).

gleysolic soil: The profile developed on wetlands, characterized by poor structure and by mottled or dull colours due to lack of aeration. Associated with **hydrophytes.**

groundwater: Subsurface water as distinct from surface water. Groundwater may lie in aquifers or it may move to the surface and **discharge.** The groundwater is **recharged** by flow from surface to subsurface.

growing degree days: The sum of daily temperatures in excess of 5°C over the growing season, averaged for a number of years.

habitat: Landscapes suited to the food and shelter requirements of animals including man.

halophyte: A plant adapted to and tolerant of a saline environment.

hydrophyte: A plant adapted to and tolerant of a wet environment.

ice-marginal channel: A valley cut by a meltwater stream flowing parallel to and beside the edge of a glacier.

kame: A mounded landform composed of roughly sorted sand and gravel deposited by meltwater in or against ice. Cf: **stratified drift.**

lacustrine deposits: Sediments settled out of lake waters.

land: A general term for the earth's surface and for the large or small areal parts of the biosphere. Syn: **landscape, landscape ecosystem, terrain.**

landform: A surface geological feature characterized both by shape and by substance; e.g. a dune is a landform with a characteristic shape (hill) and substance (sand). Four classes are distinguished: a) glacial landforms, b) proglacial (beside the glacier) landforms, c) postglacial (since glaciation) landforms, d) residual or preglacial landforms.

landscape: The visible scene of landforms capped by layers of soil, biota, climate and associated water bodies. Local landscapes are those of intermediate size that constitute the immediate environment of towns and farmsteads.

levee: A channel-side ridge formed where floodwaters drop sediments as they overtop the bank.

Life Zone: A major geographic region characterized by distinctive zonal soils, macroclimate, biota and land use. Saskatchewan is divided into nine Life Zones.

limestone: Calcium carbonate rock ("fizzes" with dilute hydrochloric acid). Cf: **dolomite.**

marsh: A wet grassy landscape.

meander: A sinuous curve or loop in a stream.

meander scroll: One of a series of curved ridges and associated troughs formed on the inside of a migrating stream meander. Cf: **point bar deposits.**

meltwater channel: A valley cut out by glacial meltwater. Cf: **spillway, coulee.**

moraine: A landform composed mostly of **till.** According to their surface appearances, moraines are described as featureless, rimmed kettle, linear ridge, washboard, drumlinized and fluted, hummocky, and end (high ridged).

moraine plateau: A level lacustrine deposit surrounded by moraine with a hilly topography. The origin is believed to be an ice-walled lake on the moraine.

net radiation: The difference between incoming radiation and outgoing radiation; the amount available for warming objects and for evaporating water.

organic soil: Peatland profile of **fen** or **bog,** low in mineral content.

outwash: Stratified, usually coarse sediments (sand and gravel) washed out from a glacier and deposited beyond its margin. If the surface is marked by kettles, it is **pitted outwash.**

oxbow lake: An abandoned **meander loop,** retaining water, on a floodplain.

phenology: Study of periodic biological events in relation to climate.

piedmont plain: An apron of sediments at the foot of a highland (literally "at the foot of the upland").
piping: Erosion of a subsoil layer by springs emerging on a slope.
podzolic soil: Forestland profile usually characterized by a superficial litter layer, a leached Ae horizon and a B horizon enriched from above with humus, clay or iron.
point bar deposits: The series of curved ridges and associated troughs formed on the inside of migrating stream meanders. Cf: **meander scroll.**
postglacial: Having to do with the recent time period, since glaciation ended.
proglacial: Adjacent to (in front of or beside) a glacier, applied especially to ice-dammed lakes and to stratified drift deposits.
re-entrant: The notch between two lobes, as an indentation on the margin of a glacier. Ant: salient.
regosolic soil: Weakly developed profile or none, due to erosion, deposition, or to an intractable substratum.
saline: Enriched with soluble sodium and magnesium salts, chiefly sulfates and chlorides.
sediments: General term for materials deposited by ice, water or air; more strictly, the mineral materials that settle out of water.
series: Unit of soil classification comprising one or several associated catenary members sharing a similar environment.
soil: The surface stratum on landforms, the rooting zone of plants, and an essential structure of landscape ecosystems.
solonetzic soil: Saline land profile usually characterized by a chernozemic A horizon, a hard intractable B and salt crystals in the C.
spillway: The drainage channel of a lake, usually a proglacial lake. Cf: **coulee, meltwater channel.**
stratified drift: Sediments deposited by glacial meltwater. They may be **coarse stratified drift** as in stream-deposited gravelly-sandy eskers, kames, outwash or **fine stratified drift** as in lake-deposited silty or clayey lacustrine sediments.
terrace: A bench or step-like ledge often occurring along a valley side, marking a former level of the river.
terrain: A local tract of land with its natural features of vegetation, soil and climate. Cf: **local landscape, landscape ecosystem.**
till: Unsorted debris deposited by glaciers and usually consisting of a heterogeneous mixture of clay, silt, sand and stones. Cf: **moraine.** Syn: **glacial till.**
till plain: A low-relief landform mostly composed of glacial till. Cf: **eroded till plain.** Syn: **ground moraine.**
topoclimate: Climate near the ground, "attached to" the landscape and varying with topography.
valley fill: Alluvium deposited in and building up the bottom of a previously excavated valley.
valley train: Coarse outwash deposited in and along the margins of a meltwater stream, today occurring in valleys as old **bars** and **terraces.**
varve: A thin layer of lacustrine material believed to represent one year's sedimentation.
water deficit: The average difference between yearly precipitation and potential evapotranspiration, the latter being the amount of water that could be evaporated if it were freely available at all times.

VII. References and Sources

Chapter II

There are not many books devoted exclusively to "landscape ecology" and most references to the subject are tucked away in texts on vegetation, climate and soils. Ecology books are useful sources. Although they concentrate on the general processes of ecosystems (the cycling of materials, the flow of energy), they usually devote chapters to the interrelationships of organisms with the air and earth strata. The author has discussed a rationale for landscape ecology in several articles:

Rowe, J. S. 1961. The level-of-integration concept and ecology. *Ecology* 42: 420-427.

Rowe, J. S. 1969. Plant community as a landscape feature. p. 63-81. In K. N. H. Greenidge (ed.), *Essays in Plant Geography and Ecology*. The Nova Scotia Museum, Halifax, N. S.

Chapters III & IV

The best general reference is the *Atlas of Saskatchewan* because it contains information on all aspects of landscapes.

General

Richards, J. H. and K. I. Fung. 1969. *Atlas of Saskatchewan*. University of Saskatchewan, Saskatoon.

Physiography

Acton, D. F., J. S. Clayton, J. G. Ellis, E. A. Christiansen and W. O. Kupsch. 1960. *Physiographic Divisions of Saskatchewan* (an annotated map). Saskatchewan Soil Survey, University of Saskatchewan.

Bedrock and Subsurface Geology

Whitaker, S. H. and D. E. Pearson. 1972. *Geological Map of Saskatchewan*. Department of Mineral Resources and the Saskatchewan Research Council, Province of Saskatchewan.

Glacial and Surface Geology

Christiansen, E. A. 1956. *Glacial geology of the Moose Mountain area, Saskatchewan*. Saskatchewan Department of Mineral Resources Report 21.

Christiansen, E. A. 1959. *Glacial geology of the Swift Current area, Saskatchewan*. Saskatchewan Department of Mineral Resources Report 32.

Christiansen, E. A. 1960. *Geology and ground-water resources of the Qu'Appelle area, Saskatchewan*. Saskatchewan Research Council, Geology Division Report 1.

Christiansen, E. A. 1961. *Geology and ground-water resources of the Regina area, Saskatchewan*. Saskatchewan Research Council, Geology Division Report 2.

Christiansen, E. A. 1965. *Geology and ground-water resources of the Kindersley area (72-N), Saskatchewan*. Saskatchewan Research Council, Geology Division Report 7.

Christiansen, E. A. (Ed.), 1970. *Physical environment of Saskatoon, Canada*. National Research Council Publication No. 11378, Ottawa.

Greer, J. E. and E. A. Christiansen, 1963. *Geology and ground-water resources of the Wynyard area (72-P), Saskatchewan*. Saskatchewan Research Council, Geology Division Report 3.

Parizek, R. R. 1964. *Geology of the Willow Bunch Lake area (72-H) Saskatchewan*. Saskatchewan Research Council, Geology Division Report 4.

Scott, J. S. 1962. *Surficial geology of Elbow map-area, Saskatchewan*. Geology Survey Canada Paper 61-15, Ottawa.

Groundwater, Pregiacial Land Surface, Buried Valleys, etc.

A series of annotated maps prepared by Saskatchewan Research Council personnel (chiefly E. A. Christiansen, W. A. Meneley and S. H. Whitaker) covers most of the south half of the province. Note that some of Christiansen's reports, previously listed, contain sections on groundwater resources. The following maps were available from SRC in 1976:

Weyburn Area (62-E, F)
Wood Mountain Area (72-G)
Regina Area (72I)
Prelate Area (72-K)
Rosetown Area (72-O)
Melfort Area (73-A)
Battleford Area (73-C)
Shellbrook Area (73-G)
Waterhen River Area (73-K)
Willow Bunch Area (72-H)
Melville Area (62-K, L)
Swift Current Area (72J)
Yorkton Area (62-M, N)
Wynyard Area (72P)
Hudson Bay Area (63-C, D)
Saskatoon Area (73-B)
Prince Albert Area (73H)
St. Walburg Area (73F)

Soils

Two early reports, with maps, describe the soil associations of the agriculturally-settled parts of southern Saskatchewan. More detailed recent reports (not listed) are available from the Saskatchewan Institute of Pedology, University of Saskatchewan, covering the following map areas:

Willow Bunch Lake (72H)
Rosetown (72-O)
St. Walburg (73F)
Regina (72I)
Shellbrook (73G)

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Chapter V

The first references have to do with the philosophy and goals of ecological land use planning. The Canada Land Inventory maps give specific data on the landscapes of southern Saskathcewan and on their suitabilities and capabilities for the uses of agriculture, forestry, wildlife (ungulates and waterfowl) and recreation.

Ehrenfeld, D. W. *Biological Conservation.* Holt, Rinehart and Winston, Inc., Toronto.
Juzek, C. and S. Mehrtens. 1974. *Earthkeeping: Readings in Human Ecology.*

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Saskatchewan Environmental Advisory Council First Annual Report, 1974. Public Information Division, Department of the Environment, Regina.
Canada Land Inventory maps for southern Saskatchewan, assessing the capabilities and suitabilities of the land for agriculture, forestry, wildlife and recreation. Available from the Lands Directorate, Environment Canada, Ottawa.

Of General Interest

The Blue Jay —
A journal of natural history and conservation for Saskatchewan and adjacent regions. Published quarterly by the Saskatchewan Natural History Society. Editor 1976, Bernard Gollop. $5.00 per year.

Enivronment PROBE -
An environmental magazine published bi-monthly by the Saskatoon Environmental Society. Editor 1976, Mr. J. F. C. Wright. $3.00 per year.

Flora and Fauna

A. C. Budd and K. F. Best. *Wild plants of the Canadian Prairies.* Publication 983 - 1964, Research Branch, Canada Department of Agriculture, Canada.
A. W. F. Banfield. *The mammals of Canada.* Published for the National Museum of Natural Sciences, National Museums of Canada, 1974, by the University of Toronto Press.
Roger Tory Peterson. *A field guide to western birds.* Houghton Mifflin Company, Boston.

Some References for Field Trip Studies

The following is a partial list of publications relating to Saskatchewan natural history. They are grouped under headings which indicate the source from which they may be obtained. Costs vary.

Saskatchewan Museum of Natural History
Department of Culture and Youth
Wascana Park
Regina, Saskatchewan

Reptiles of Saskatchewan's Ancient Seas 12pp
Concretions and Some Other Sedimentary Structures 20pp
Grouse and Introduced Game Birds of Saskatchewan 16pp
Some Winter Birds of Saskatchewan 20pp
Swans, Geese, Ducks and Cranes of Saskatchewan 24pp
Big Game Animals of Saskatchewan 16pp
Fur Bearing Animals of Saskatchewan 20pp
Amphibians and Reptiles of Saskatchewan 40pp
Exploring the Dunes (Goodspirit Lake Provincial Park) 12pp
The Bison and Man 26pp
The Cypress Hills - A Natural History 28pp
Douglas Provincial Park - A Natural History 28pp
Sport Fishes of Saskatchewan
Trees and Shrubs of the Qu'Appelle Valley
Woodland Wildflowers of Eastern Saskatchewan 67pp
Saskatchewan Wildflowers - Western Area 108pp
Common Marsh Plants of Saskatchewan 40pp
Birds of Moose Mountain
Birds of the Lake Athabasca Region
Butterflies of Saskatchewan
Meadow Lake Geolog
Fort Qu'Appelle Geolog

Qu'Appelle Implementation Office
Fort Qu'Appelle, Saskatchewan

Marsh Life of the Qu'Appelle
Fish of the Qu'Appelle Valley
Bird Life in the Qu'Appelle Valley
Flowering Plants of the Qu'Appelle
Mammals in the Qu'Appelle Valley

Canadian Wildlife Service
Prairie Wildlife Interpretation Centre
P.O. Box 10, Webb, Saskatchewan

A Piece of Prairie

Big Muddy Tour Association
Big Beaver, Saskatchewan

Big Muddy Country

Tri-Leaf Publications
843 Temperance Street
Saskatoon, Saskatchewan

Saskatchewan Trees (Teed & Rowe)

At Local Bookshops and Libraries:

Best, K. F., Jan Looman & J. B. Campbell (1971)
Prairie Grasses. Agriculture Canada.

Campbell, J. B., K. F. Best & A. C. Budd (1966)
Ninety-nine Range Forage Plants of the Canadian Prairies. Agriculture Canada.

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Peterson, R. T. (1961)
A Field Guide to Western Birds. Houghton Mifflin, Boston.

Robbins, Bruun, Zim & Singer (1966)
Birds of North America. Golden Press, New York.

Vance, F. R., J. R. Jowsey, F. S. McLean (1977)
Wildflowers Across the Prairies. Western Producer Books, Saskatoon.

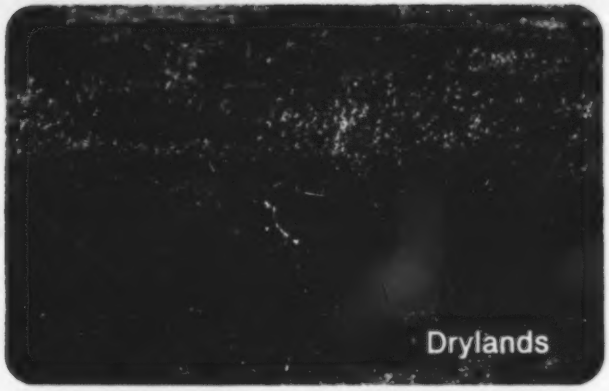
Gilroy, D.
Parkland Portraits. Western Producer Books, Saskatoon.

Burt, W. H. & R. P. Grossenheider (1952)
A Field Guide to the Mammals. Houghton Mifflin, Boston.

Murie, O. J. (1954)
A Field Guide to Animal Tracks. Houghton Mifflin, Boston.

Hosie, R. C. (1966)
Native Trees of Canada. Queen's Printer.

Bird, R. D. (1961)
Ecology of the Aspen Parkland of Western Canada. Agriculture Canada.



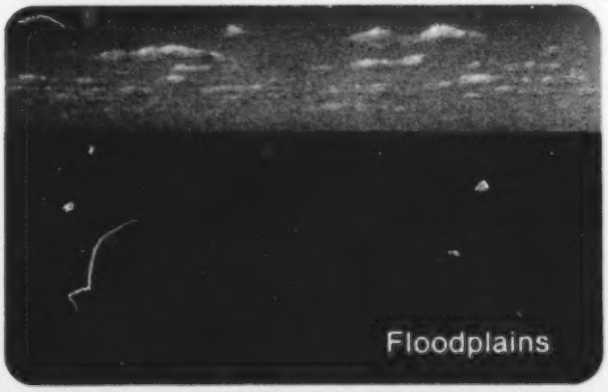
Landscapes:

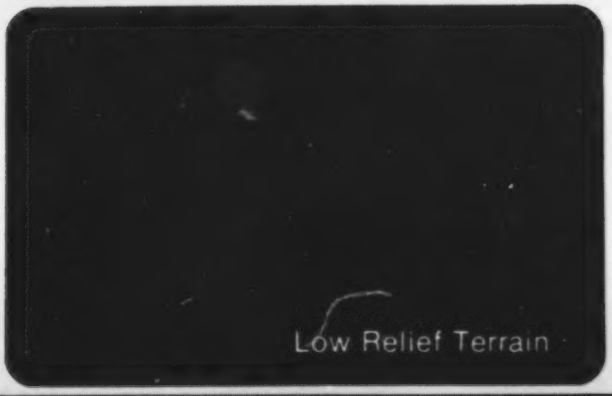
A Guide to the Landforms and Ecology of Southern Saskatchewan

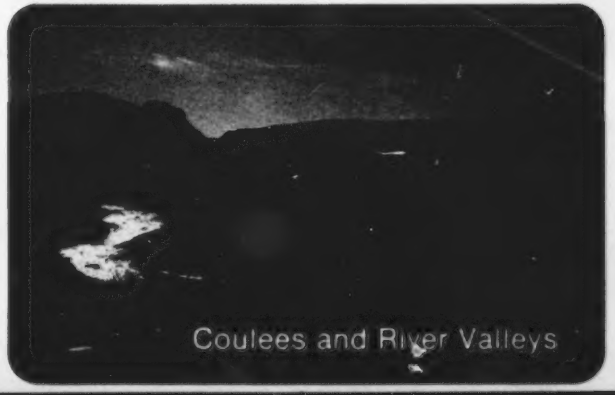
A Resource Kit for Teachers

Saskatchewan Environment
Public Information and Education Branch
Ted Bowerman, Minister

106







Landscapes

... a Reason for Everything

There is a reason for everything in nature. There is no mystery, no magic - only natural events and processes that can be studied and explained. Every hill and river, every wildflower and grain of sand has a story to tell if we have the wisdom to ask the right questions.

By asking the right questions, we can understand how Saskatchewan's landscapes evolved into what they are today. By studying their ecology, we gain insight about how the world ecosystem operates. We appreciate nature's delicate balances. We learn to question the wisdom of land uses.

... from Landform to Landscape

A landscape is more than just a piece of ground. It gains its physical properties from a landform of geological material, and in our area that usually means something created and left by the great continental glaciers. Each landform affects the climate on its surface. Conditions are different on hilltops, slopes and low spots. Different plant communities become established, and in turn influence further changes in the landform and the local climates.

A landscape is a landform, along with its associated local climates and plant communities.

... a Framework for Study

Landscapes are an excellent framework for studying the natural sciences. Each is an ecological system in which we can see the relationships between land and air, water and living organisms. Each landscape is the world in miniature, yet they are an ideal size for study. They are small enough to be familiar and readily comprehended by students.

A Resource Kit for Teachers

Ecology is a complex topic which can be simplified by using the local landscape as a framework. But still, it requires knowledge from all of the natural sciences; geology, biology, hydrology and climatology. There are even aspects of sociology and psychology when human involvement is studied.

To make it easier for teachers to conduct studies in landscape ecology, **Saskatchewan Environment** has produced a kit of resource materials. Included are adequate resources for any program - from a few hours of classroom discussion, to a lengthy and comprehensive program of field trips and student research.

... a Reference Manual

Written by Professor J. Stan Rowe (University of Saskatchewan) and edited by naturalist Robert Long, the reference manual explains the principles of ecology and geology necessary to understand landscapes. The manual's theme is "earth care". It relates human values and activities to the laws of nature seen in landscapes.

... Landscape Guides

Every site in southern Saskatchewan can be assigned to one of seven landscape types. These are discussed in a series of audio/visual programs (slide/tape or video cassette). A printed version of each guide provides a portable reference for use in the field, or for individual student research. Printed guides include additional information, illustrations, and suggestions for activities in the field.

... a Landscape Map

A unique representation of Saskatchewan south of Prince Albert, the landscape map will allow anyone to identify areas of each landscape type nearest their location. The map was compiled especially for this kit by Dr. D. F. Acton of Agriculture Canada.

... and Posters

a series of seven full colour posters, measuring 46 × 61 cm., representing the seven landscapes, may be used as demonstrations or as classroom displays.

Acquiring the Landscapes Kit

"Landscapes" is available on loan through the SASKMEDIA Film Library. Complete kits in slide/tape format may be purchased at a cost of $350.56; on video cassettes, $112.00. Or each separate slide/tape program may be purchased at a cost of $50.08; on video cassette, $16.00. Reference manual is available separately.

Please address order and inquiries to:

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1112 Winnipeg Street,
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S4P 3S7